COPY FOR MR. J. ALLAN ROSS

HYDRO-ELECTRIC INQUIRY COMMISSION

ENGINEERING DATA

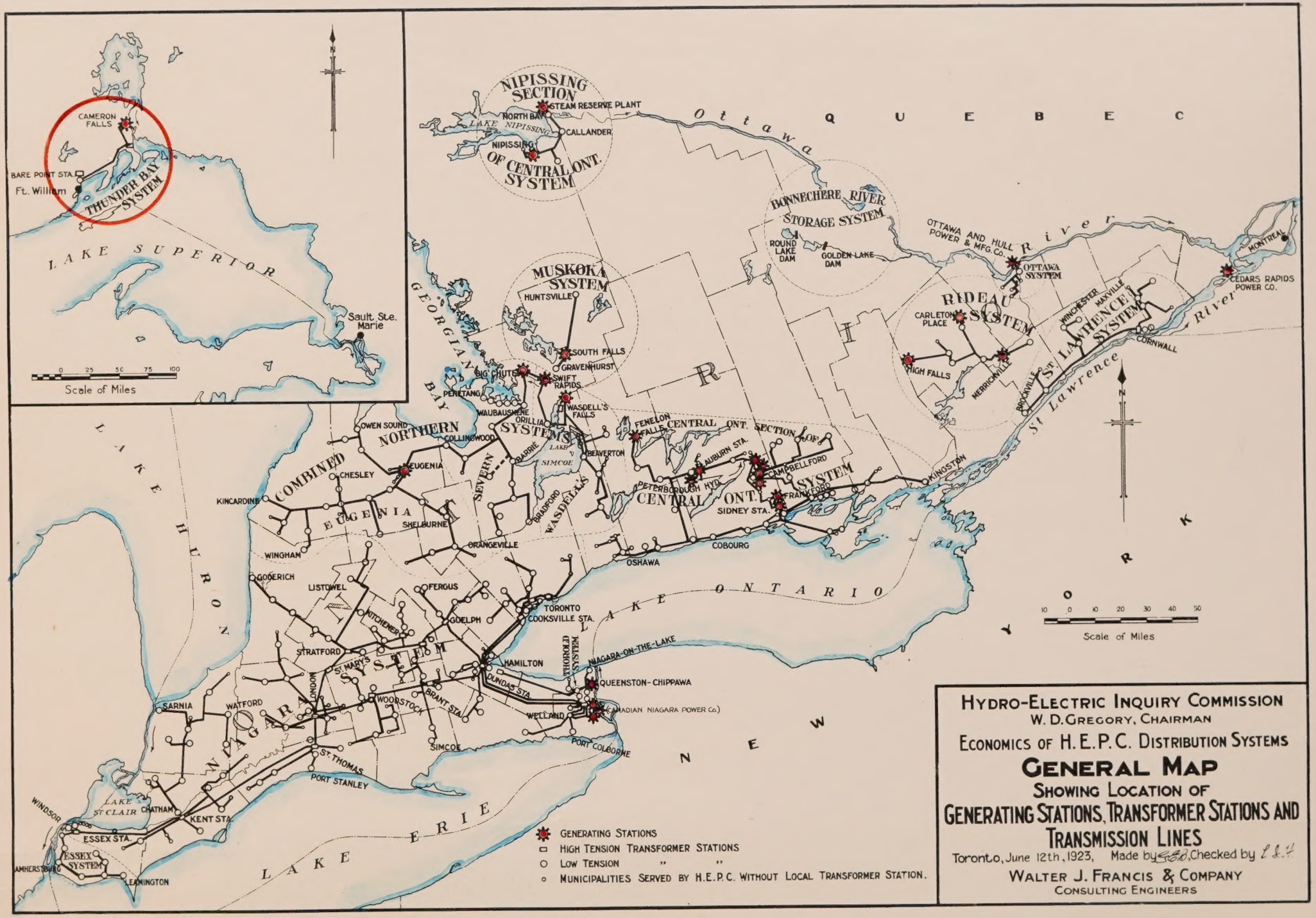
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

STUDY OF THUNDER BAY SYSTEM

WALTER J. FRANCIS & COMPANY

CONSULTING ENGINEERS

THUNDER BAY SYSTEM


HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
GENERAL MAP
SHOWING LOCATION OF
GENERATING STATIONS, TRANSFORMER STATIONS AND TRANSMISSION LINES
Toronto, June 12th, 1923, Made by G.S.B. Checked by L.L.H.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS
GENERATING STATIONS
HIGH TENSION TRANSFORMER STATIONS
LOW TENSION " "
MUNICIPALITIES SERVED BY H.E.P.C. WITHOUT LOCAL TRANSFORMER STATION.
Scale of Miles
LAKE SUPERIOR
LAKE HURON
LAKE ONTARIO
LAKE ERIE
LAKE ST CLAIR
GEORGIAN BAY
QUEBEC
NEW YORK
Ottawa River
St Lawrence River
NIPISSING SECTION OF CENTRAL ONT. SYSTEM
STEAM RESERVE PLANT
NORTH BAY
CALLANDER
NIPISSING
LAKE NIPISSING
MUSKOKA SYSTEM
HUNTSVILLE
SOUTH FALLS
GRAVENHURST
BIG CHUTE
SWIFT RAPIDS
WASDELL'S FALLS
PERETANG
WAUBAUSHENE
ORILLIA
BONNECHERE RIVER STORAGE SYSTEM
ROUND LAKE DAM
GOLDEN LAKE DAM
OTTAWA AND HULL POWER & MFG. CO.
OTTAWA SYSTEM
RIDEAU SYSTEM
CARLETON PLACE
HIGH FALLS
MERRICKVILLE
WINCHESTER
MAXVILLE
BROCKVILLE
ST. LAWRENCE SYSTEM
CORNWALL
MONTREAL
CEDARS RAPIDS POWER CO.
COMBINED NORTHERN SYSTEMS
OWEN SOUND
COLLINGWOOD
BARRIE
LAKE SIMCOE
BEAVERTON
SEVERN
WASDELAKS
BRADFORD
EUGENIA
CHESLEY
KINCARDINE
SHELBURNE
ORANGEVILLE
WINGHAM
GODERICH
LISTOWEL
FERGUS
GUELPH
KITCHENER
STRATFORD
ST. MARYS
WOODSTOCK
BRANT STA.
SIMCOE
ST. THOMAS
PORT STANLEY
SARNIA
WATFORD
WINDSOR
CHATHAM
KENT STA.
ESSEX STA.
ESSEX SYSTEM
AMHERSTBURG
LEAMINGTON
NIAGARA SYSTEM
HAMILTON
DUNDAS STA.
THOROLD SYSTEM
NIAGARA-ON-THE-LAKE
QUEENSTON-CHIPPAWA
WELLAND
(CANADIAN NIAGARA POWER Co.)
PORT COLBORNE
TORONTO
COOKSVILLE STA.
OSHAWA
COBOURG
PETERBOROUGH HYD.
CENTRAL ONT. SECTION OF CENTRAL ONT. SYSTEM
FENELON FALLS
AUBURN STA.
CAMPBELLFORD
FRANKFORD
SIDNEY STA.
KINGSTON
CAMERON FALLS
BARE POINT STA.
Ft. William
THUNDER BAY SYSTEM
Sault. Ste. Marie
Scale of Miles

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.
To face frontispiece.

General Map Showing Location of

Generating Stations, Transformer Stations and Transmission Lines

of the

Hydro-Electric Power Commission of Ontario.

The area outlined in red shows the

Thunder Bay System.

Engineers of N.E.P.C. Contracting
General Map
Showing Location of
Generating Stations, Substations
Transmission Lines
Scale: 1 Inch = 1 Mile
Section of Ontario
Low Tension
Hydro-Electric Power Commission of Ontario
Supplied by N.E.P.C. Without Local Transformer Station.

INDEX TO THUNDER BAY SYSTEM

Index to Contents of Volume

INDEX TO THUNDER BAY SYSTEM

LIST OF ILLUSTRATIONS

THUNDER BAY SYSTEM

(Illus.)

LIST OF ILLUSTRATIONS

CONTENTS: LIST OF FIGURES

WALTER J. FRANCIS & COMPANY.

COPY FOR ENCLOSURE TO Mr. J. Allan Ross.

Toronto, Ontario,

June 20th, 1923.

Hydro-Electric Inquiry Commission,
W. D. Gregory, Esq., Chairman.
T O R O N T O, Ontario.

re Studies of Engineering Economics of the
Thunder Bay System of the
Hydro-Electric Power Commission of Ontario.

Mr. Chairman and Gentlemen,-

In accordance with the letter to your Commission under date of November 4th, 1922, and your confirmation of the general instructions under date of November 15th, 1922, a study has been made of the engineering economics of the Thunder Bay System of electrical generation and distribution operated by the Hydro-Electric Power Commission of Ontario. The work has been done under the direct personal supervision of Mr. Frederick B. Brown, M. Sc., M.E.I.C., a partner in the firm of Walter J. Francis & Company, in accordance with your instructions.

The subject has been discussed with Mr. Commissioner R. A. Ross in detail, and, generally, with Mr. Bower, the Secretary of your Commission, and constant communication has been maintained with the officials of the Hydro-Electric Power Commission of Ontario.

The reports of Messrs. Price, Waterhouse & Co. have been used as the basis of the financial figures given herein, and reference has been made to the records of the Hydro-Electric Power Commission of Ontario where it was necessary

to do so to prepare the diagrams.

It is understood that it is not within the scope of the instructions to examine into any of the legal aspects of the System nor discuss any of the Acts of the Legislature relating to it.

The necessary technical data has required considerable preparation as much of it is only available in the operating records of the Hydro-Electric Power Commission of Ontario. The printed reports contain a part, but these have had to be supplemented by interviews with various officials, and by searching the voluminous records both at the head office in Toronto and elsewhere.

The general plan under which the report of the studies is presented may be outlined as follows:

(1) A short review of the history and evolution of the System.

(2) A brief physical description of the System.

(3) A brief discussion regarding the characteristics of the local market.

(4) A discussion of progressive capital costs.

(5) Statistics regarding progressive revenues for various classes of service with discussion thereon.

(6) Statistics regarding progressive operating costs and fixed charges, with discussion thereon.

(7) A brief discussion of the reserve accounts.

(8) Statistics showing progressive and accumulated deficits or surpluses, with discussion thereon.

(9) Analysis of progressive operating records and of unit revenues per

is or is to provide the illusion.

It is important that it is not which the "copy" of the instrument is another into any of the local laws of its origin or any of the laws of the Expiratory relationship it.

The necessary required one-ten required considerable preparation as was, as it is truly realistic in the operation energy of the Corporation's Inner Simulation of Interest. The original research consists years, but there have had to be supplemented by independent with various difficulty, and by assuming the relationship which is the best effort to provide and effectively.

The general plan which is the report of the studies is presented may be outlined as follows:

(1) A short review of the history and evolution of the System.

(2) A brief physical description of the System.

(3) A order elongation requiring the characteristics of the local matrix.

(4) A discussion of progressive capital costs.

(5) Statistics regarding transmitting frequency for various diameter of matrix with diameter shown.

(6) Statistics regarding preliminary transmitting costs and total charges, with diameter shown.

(7) A brief discussion of the reserve accounts.

(8) Statistics showing requirements and accumulated capital as indicated, with diameter shown.

(9) Analysis of accumulated capital which is most economical for

horse-power per annum and of unit costs per horse-power per annum.

(10) A brief discussion of the various important points concerning the System.

The report included herewith as pages 4 to 56 inclusive refers in detail to that portion of the activities of the Hydro-Electric Power Commission known as the Thunder Bay System. References are made to the inter-connection of this System with other Systems.

Throughout the report diagrams have been included in the order of the text, while the map included as a frontispiece shows the System generally and its geographical relation to all the other Systems operated by the Hydro-Electric Power Commission of Ontario.

Electro-power gas engine may, of course, derive power from any common [illegible] of energy such as the various hydrocarbon petroleum products.

Type Gas.

The primary batteries hereofile as pages 4 to 8 constitute means to extract by that portion of the electricity in the Light-Electric Power Generation system as the chemical day dynamo. Hydrocarbon gas made by the [illegible] of this system with other [illegible].

Electrolysis the [illegible] stages have been considered in the order of the [illegible], which has been indicated as a [illegible] above the [illegible] and its [illegible] relation to all the other systems [illegible] by the Light-[illegible] [illegible] [illegible].

THUNDER BAY SYSTEM

Frederick B. Brown, M. Sc.

Evolution and Development of the System.

The Thunder Bay System as it now exists is the result of the efforts of Port Arthur and Fort William to obtain a supply of power from the Hydro-Electric Power Commission of Ontario sufficient to provide for their present and future requirements. These two cities are at the head of navigation on the Great Lakes, and are situated on three transcontinental railways. The surrounding district is rich in natural resources and is well supplied with water powers which are essential to its future development.

In the early days Port Arthur and Fort William employed steam plants to supply their power requirements, but the price of coal was high and electric power was therefore expensive.

In 1901 Port Arthur constructed a hydro-electric development on the Current River within the limits of the City, which at present has an installed turbine capacity of about 2,350 horse-power. This plant has given splendid service and has been a great asset to the city. The growing demand for power, however, soon made it necessary to obtain a further supply, and in August, 1906, the civic officials began negotiations with the Hydro-Electric Power Commission of Ontario for a supply of 1,000 horse-power. In February, 1907, a by-law was passed authorizing the mayor and the city clerk to execute an agreement with the Hydro-Electric Power Commission for a supply of power.

THOMAS RAY LIMITED

Frederick B. Brown, M. Sc.

Existing and Development of the Area.

The Thomas Ray Group of Companies in Cape Breton is the remnant of the estate of Percy Stephen and Chief Utility in Canada a supply of power from the Grand-Lake-Lake Power Commission - a Crown Company - which is sufficient to provide for their present and future requirements. These two plants are at the head of navigation on the Grand Lake, and are situated on the Transcontinental railway. The surrounding district is rich in mineral resources and is well supplied with water powers which are essential in the future development.

In the early days this district and this utility employed steam plants to supply their power requirements. But the price of coal was high and electric power was therefore expensive.

In 1904 Percy Stephen constructed a hydro-electric installation on the Grand River which was later at the time, which at present has an installed capacity of about 1,500 horse-power. This plant has given satisfactory service and has been a great asset to the city. The growth demand for power, however, made it necessary to obtain a further supply, and it became the Grand-Lake, the area's principal power consumer, which is a supply of 1,000 horse-power. In Parry's, Ltd., a by-law was passed authorizing the mayor and the city clerk to execute an agreement with the Grand-Lake Power Commission for a supply of power.

It was first suggested that a development should be constructed at Dog Lake (sometimes referred to as Silver Falls), but after careful investigation it was considered best to secure additional power for Port Arthur from the Kaministikwia Power Company, which during 1905 and 1906 had installed a plant at Kakabeka Falls, about 19 miles from Fort William on the Kaministikwia River.

On September 9th, 1909, a contract was executed between the Hydro-Electric Power Commission of Ontario and the Kaministikwia Power Company for the supply of a minimum of 1,000 horse-power to a maximum of 10,000 horse-power at the following rates:

$17.00 per horse-power for all power billed to the Commission up to 2,000 h.p.

$16.00 per horse-power for all power billed to the Commission when the demand is from 2,000 to 4,000 h.p.

$15.00 per horse-power for all power billed to the Commission when the demand is from 4,000 to 6,000 h.p.

$14.00 per horse-power for all power billed to the Commission when the demand is from 6,000 to 10,000 h.p.

The contract covered a term of ten years, dating from the expiration of a 90-day notice to be given not later than January 31st, 1910. Such notice was given under date of January 27th, 1910, but, subsequently, due to the fact that Port Arthur was not ready to receive power until December 20th, 1910, it was agreed that the 10-year period should start on December 21st, 1910.

The contract also gave the Commission the option of extending the agreement for one, two or three further periods of 10 years by giving notice of

its desire for such extension three years before the expiration of the term of years then in force.

An important reservation made in Clause C, Section 3, of the contract provided as follows: "If, after the Commission has ordered 5,000 horse-power and a further order is given and the Company has no power beyond 5,000 horse-power, the Commission shall release the Company from all covenants to furnish power over the said 5,000 horse-power or procure the right for the Company to develop the water power at Silver Falls".

This Clause apparently implies, first, that the Commission under certain circumstances could not claim more than 5,000 horse-power, and second, that the Company could not develop the power site at Silver Falls, or Dog Lake, unless the Commission took action in the matter.

The Kaministikwia Power Company agreed to transmit power over its own lines to a point not more than two miles from its existing high voltage transmission line at Fort William.

The Commission, having thus made a contract for a supply of power, on January 3rd, 1910, made a contract with the City of Port Arthur to supply power to it at cost, and called for tenders for the construction of a distributing station and the necessary transmission lines.

Two transmission lines on separate poles were built to carry the power from the Power Company's lines near Fort William to the distributing station at Port Arthur, and were ready for operation at the end of 1910, but were finally completed only in the spring of 1911. The distributing station was equipped for a capacity of 2,250 kv.a. at 2,200 volts.

his desire for such concessions which prior talks the negotiations of the were of years than in force.

As Sandland pointedly made in Canada 2, section 2, of the Ontario Jewelled Watches Act, "If, after the commencement of this Act, a motor vehicle is driven into Ontario by a person not the owner thereof, or a motor vehicle is driven out of Ontario, the duration period shall commence from all movements of vehicles prior to the 1st July 1,[illegible] to provide the right for the Company to develop the water power as Silver Falls".

This clause apparently ignored, first, that the executive under service commissioner could not also take the 5,000 horse-power, and second, that the company could not develop the water at Silver Falls, or for this, without the Dominion task action in the matter.

The Tunnelinda Power Company agreed to transmit power and its was times to a point [illegible] line not other from its existing 33kv transmission line at Port William.

The Commissioner, Patrick Lake made a contract for a supply of power, on January 5th, 1920, made a contract with the city of Port Arthur to supply power in 33 kv line, and called the market for the generation at a distribution station where the necessary transmission lines.

The transmission line to Lakeview plant were built to carry the power from the Lake Superior's lines that were within 5 the distributing stations at Port Arthur, and Fort William, and were ready for operation as and and if 1920, but were totally unfitted for the trying of 1921. The distributing lines were equipped for a capacity of 5,000 kw.s. at 2,300 volts.

During the fiscal year ending October 31st, 1911, the load supplied to the City of Port Arthur from the distributing station of the Commission reached a maximum of about 2,000 horse-power, and, as it was estimated that the demand would increase about 50 per cent. in the near future, additional transforming equipment of 2,250 kv.a. capacity was ordered.

Following the studies of the power possibilities of the Dog Lake site made by the Commission, the Department of Public Works of the Province of Ontario provided the Dog Lake storage dams. They were designed by the engineers of the Hydro-Electric Power Commission of Ontario, and the construction was carried out under their supervision. Work was begun in the fall of 1909, and was completed in the early part of 1911. Dog Lake is said to have an area of 53 square miles. By means of this storage regulation the mean dependable flow of the river at Kakabeka Falls is estimated by the engineers of the Commission to be 1,000 cubic feet per second. The Kaministikwia Power Company is the only company to benefit by this water regulation, and the operation of the sluice gates is under their charge. It is stated that this Company has a perpetual franchise to develop power at Kakabeka Falls without the payment of any water rentals.

During 1912 the City of Port Arthur was granted permission to instal a 750-kv.a. motor-generator set in the Commission's substation, to convert 2,200-volt, 60-cycle alternating current to 600-volt direct current to be used for street railway operations.

As the growth of the demand for electricity in Port Arthur was rapid, and as it showed indications of exceeding the capacity of the substation,

a contract was let in 1913 for the extension of the station. On September 20th, 1913, a 22,000-volt line from the substation of the Commission to the new Government grain elevator was tested and put into service. The contract between the Dominion Government and the City of Port Arthur was for 1,000 horse-power, while the transformer capacity in the grain elevator was 2,500 horse-power. At about this time a contract was signed by Port Arthur to supply the Canadian Northern Railway elevator with 400 horse-power.

During 1913 and 1914 certain changes and improvements were being carried out at the Current River plant in accordance with the plans of the Commission. This permitted the two sources of power for the City of Port Arthur to be operated in parallel, and it is stated that the result was a direct saving in the cost of power. To insure full co-operation between the operators at the City generating station and the transformer station of the Commission, an agreement was drawn up in 1915, permitting the Commission to operate the Current River generating station with its own staff, the cost to be borne by the City.

The demand for power in Port Arthur continued to increase steadily, but the amount of power purchased by the Commission remained about the same, due to the fact that the additional load was being carried by the Current River plant. It is stated by the Hydro-Electric Power Commission that in 1917 the total power reserved for the Commission was 2,600 horse-power, and that the power taken was about 2,410 horse-power, while the power supplied by the Current River plant was about 2,000 horse-power at peak loads, the combination resulting in a load factor of about 95 per cent. in the power purchased

by the Commission. The Current River plant, however, had reached its capacity and could not be relied upon to supply more power, and therefore the amount of power purchased by the Commission was increased in 1918 to meet an increase in demand of 1,600 horse-power in that year.

At the end of 1916, it is said that the city officials of Port Arthur in a communication addressed to the Commission requested that the power contract with the Kaministikwia Power Company should not be renewed. The foremost reason given was that it was expected that the power demands of Port Arthur would exceed the available plant capacity of the Power Company. The authorities of the City of Port Arthur are said to have strongly recommended the development of the Dog Lake site, and to have requested estimates on the cost of power therefrom.

The City of Port William had been supplied with power by the Kaministikwia Power Company since 1906. The City purchased power wholesale under a contract dated March 14th, 1905, and distributed it for lighting and street railway purposes, while the Power Company was given the sole right to sell power to power consumers in Fort William taking over 25 horse-power. The agreement between these parties will expire during the month of March, 1926, following which the Power Company may sell power in the City of Fort William to whom it desires, by virtue of a perpetual franchise which it holds. The authorities of the City of Fort William have also requested estimates from the Hydro-Electric Power Commission. The Commission made studies of the cost of developing and supplying power from Cameron Falls on the Nipigon River, and also from Silver Falls on the Dog Lake site on the

Kaministikwia River. Under date of August 3rd, 1916, rates for the purchase of electric power were submitted to the City of Port Arthur, based on the delivery from the Dog Lake development at primary voltage of 40,000 volts as follows:

10,000	horse-power	delivered	at	40,000	volts	- $19.00	per	h.p.	per annum
15,000	"	"	"	"	"	16.00	"	"	"
20,000	"	"	"	"	"	14.00	"	"	"
25,000	"	"	"	"	"	13.00	"	"	"
30,000	"	"	"	"	"	11.00	"	"	"

On December 28th, 1916, prior to the time of the municipal elections at which the power by-laws were to be submitted, the Commission telegraphed its provisional rates for power from the proposed Nipigon plant applicable to both Port Arthur and Fort William, delivered at 22,000 volts.

The rates were as follows:

5,000	horse-power	each	- $26.00	per h.p.	per annum
7,500	"	"	" 18.00	"	"
15,000	"	"	" 15.00	"	"

This output was to be supplied from a 30,000-horse-power plant at Cameron Falls operating at full capacity.

A Hydro-Electric by-law was submitted to the rate-payers of Port Arthur on January 1st, 1917, and was carried by a vote of 712 for and 22 against. This was followed by the agreement of March 7th, 1917, between Port Arthur and the Commission for a supply of power when the contract with the Kaministikwia Power Company will have expired in 1920.

The Hydro-Electric enabling by-law was submitted to the rate-payers of Port William also on January 1st, 1917, and carried 700 votes for and 71 against, and on October 10th, 1917, the Commission made an agreement with Port

William to supply its power requirements above the ultimate amount included in its contract with the Power Company, and to supply the total demand on the expiration of that contract in March, 1926.

In 1916 the Ontario Department of Lands, Forests and Mines sold the right to cut certain timber limits adjacent to the Nipigon River to pulp and paper interests, and with it a lease to develop the water powers of the district. These water powers included the Cameron Falls site, and steps were at once taken by the Commission and the municipalities concerned to have these rights repealed or altered. As a result of these representations to the Provincial Government, arrangements were made whereby the water power rights were relinquished, and in lieu thereof the Crown agreed to supply the power requirements of the pulp and paper company plant at cost, through the Hydro-Electric Power Commission of Ontario.

After studying both the Dog Lake and the Cameron Falls power sites, the engineers of the Hydro-Electric Power Commission, in a report dated May 16th, 1918, strongly advised the development of the latter site on the Nipigon River. On June 26th, 1918, the Chairman of the Commission presented to Sir William Hearst, then Premier of Ontario, a formal request for an Order-in-Council to permit the construction of a generating station at Cameron Falls on the Nipigon River, having an initial capacity of 30,000 horse-power with provisions for increasing the amount to an ultimate capacity of from 60,000 to 70,000 horse-power, and to construct a double-circuit transmission line 70 miles long, together with the necessary transforming equipment to step down the voltage from 110,000 volts to 22,000 volts with a capacity

sufficient for the first stage of the development, the whole to cost $4,419,568.

The Order-in-Council authorising this work was dated July 4th, 1918, and covers the following points:

(1) The acquiring by purchase, lease or otherwise of the necessary lands, waters, water privileges and water powers for the developing of the said water power.

(2) The purchase of necessary material and equipment for construction of a plant for the generation of 30,000 horse-power of electrical energy and for its transformation for transmission to the various municipalities in that district.

(3) The purchase of necessary material and equipment for the construction of transmission lines and transformer stations for the delivery of the said power to the municipalities of the Cities of Port Arthur and Fort William, and other municipalities in that district.

Construction of the Nipigon Development was commenced on December 1st, 1918, and the work was carried on rapidly. It is stated by the engineers of the Hydro-Electric Power Commission that this resulted in heavy additional costs. The object of the speedy construction is stated to be the completion of the development so as to deliver power by December 20th, 1920. About the middle of December, 1920, one of the generators was ready for service, and shortly thereafter the transmission line to Port Arthur was also tested and found satisfactory. Power was delivered to Port Arthur on December 20th, 1920. The second unit was placed in operation on January 24th, 1921, and the whole of the work entailed in constructing the present stage of the Nipigon Development was completed by December 16th, 1921.

Description of the System.

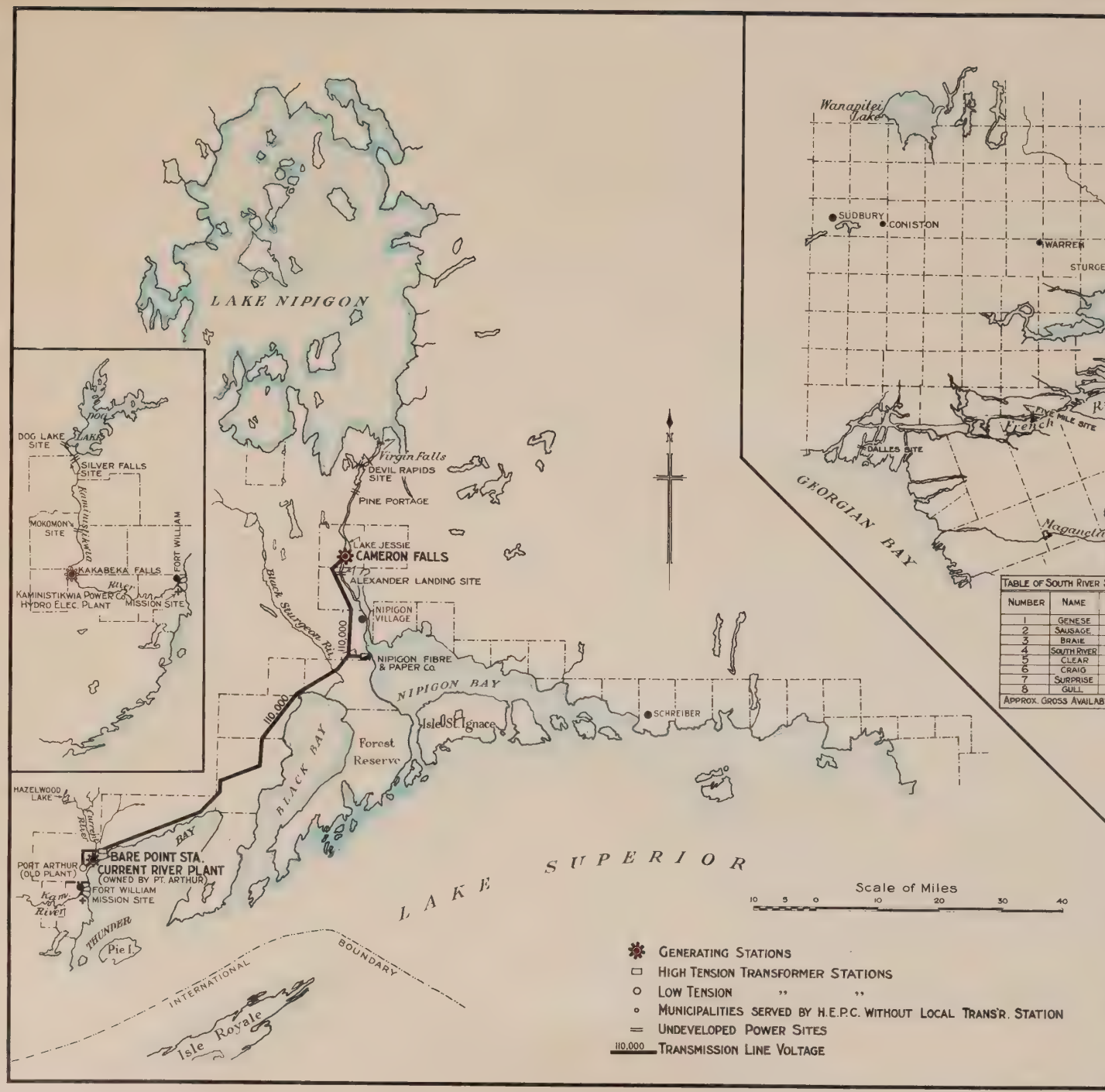
General.

The Thunder Bay System of the Hydro-Electric Power Commission of Ontario comprises a narrow strip of territory between Lake Nipigon on the north, and Lake Superior on the south, and is distant about 600 miles in a north-westerly direction from Niagara Falls. The territory includes the two cities, Port Arthur and Port William, but as yet Port William is not receiving power from the Commission.

The map included as a frontispiece shows the whole of the transmission systems of the Hydro-Electric Power Commission of Ontario with the location of the generating stations, high voltage transformer stations, high voltage transmission lines, and low voltage transformer stations, clearly indicated, and also the various Systems in their relation to one another. The tinted portion of the map contained in the insert indicates the Thunder Bay System.

The map included as page 14 shows the Thunder Bay System on a larger scale than the frontispiece, and gives the names of the principal centres concerned. It also shows, as an insert, the Nipissing Section of the Central Ontario System, which is situated about 250 miles to the east of the Thunder Bay System, and is nearer to it than any of the other Systems of the Commission.

Speaking broadly, the Thunder Bay System consists of a hydro-electric generating plant and step-up transformer equipment at Cameron Falls on the Nipigon River, transmission lines feeding one municipality and one private



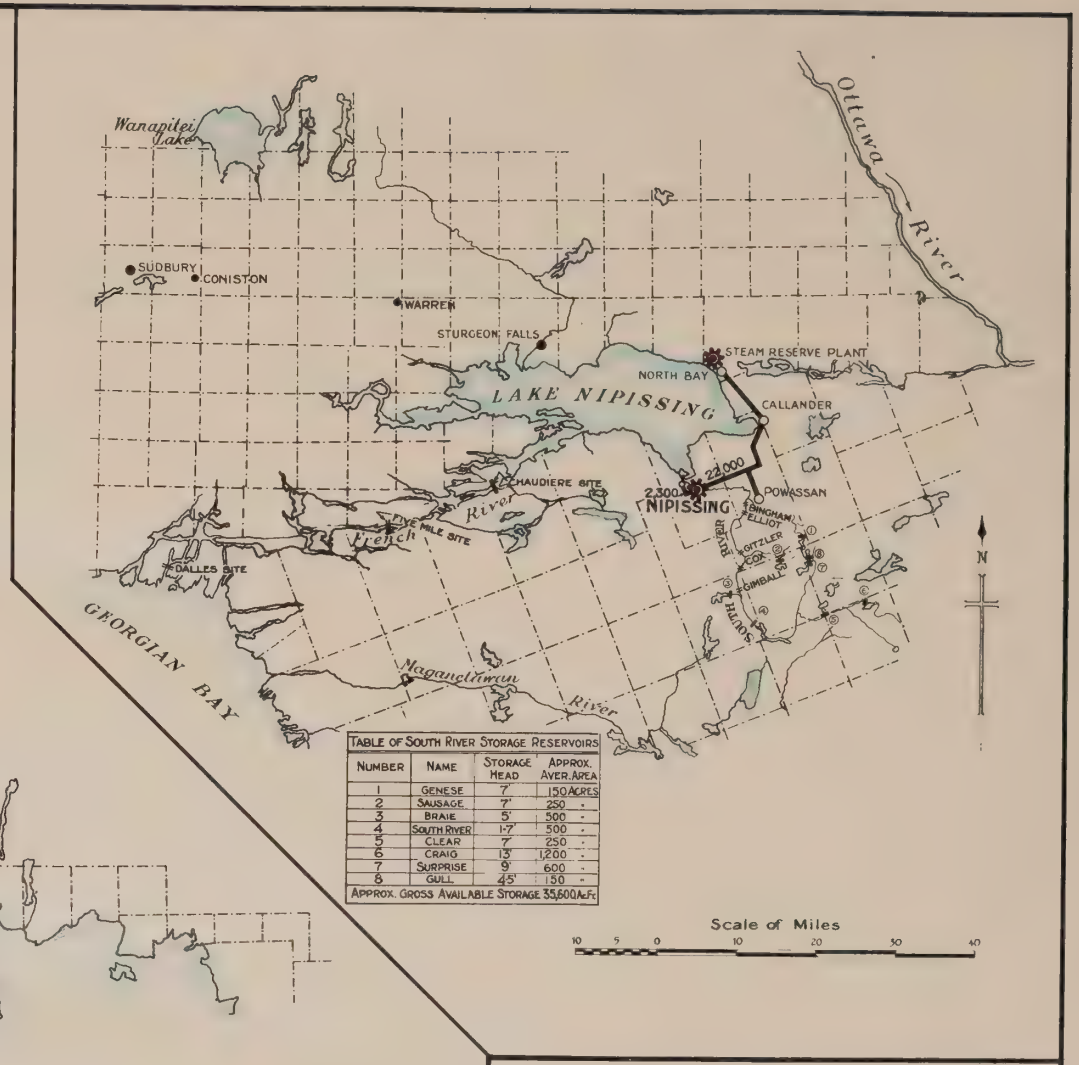


Table of South River Storage Reservoirs			
Number	Name	Storage Head	Approx. Aver. Area
1	Genese	7'	150 Acres
2	Sausage	7'	250 "
3	Braie	5'	500 "
4	South River	1-7'	500 "
5	Clear	7'	250 "
6	Craig	13'	1,200 "
7	Surprise	9'	600 "
8	Gull	4-5'	150 "
Approx. Gross Available Storage 35,600 A.Ft.			

Hydro-Electric Inquiry Commission

W. D. Gregory, Chairman

Economics of H. E. P. C. Distribution Systems

Nipissing Section of Central Ontario System, and Thunder Bay System

Map Showing Location of Generating Stations, Transformer Stations and Transmission Lines

Toronto, June 20th, 1923. Made by SRW, Checked by L.J.H.

Walter J. Francis & Company
Consulting Engineers

company, and two step-down transformer stations at Port Arthur.

Generating Station and Other Sources of Power Supply.

(a) Nipigon Development.

Since December 20th, 1920, the entire power supply for the Thunder Bay System has been generated at the Nipigon Power Development at Cameron Falls, the only plant constructed on this System by the Hydro-Electric Power Commission.

The Cameron Falls plant is situated at the lower end of Lake Jessie, an expansion of the Nipigon River. Four dams control the water level of the lake. The main dam across the river is a solid concrete, gravity-type structure, provided with eight sluiceway sections with stop-logs for the regulation of the flow of the river.

The power house is of the concentrated type of construction in which the gate-house and screen house, the penstocks, and the transformer station all form an integral part.

The substructure of the power house has an over-all length of about 315 feet, and provides for a total of six units, all of equal capacity. The present portion of the superstructure of the generating station is about 130 feet long by 150 feet wide, and about 87 feet high, and forms the housing for two of the units.

The present installation consists of two 12,500-horse-power, Francis type, single-runner, vertical turbines, each directly connected to a

Mr. J. Allan Ross.

energy, and two single-phase transformer stations of 1000 kilos.

Generating station and other features of interest.

(a) Tilsley Development.

Since December 1913, the entire power supply for the Tilsley Mills has been generated at the Tilsley Power Development on Bowers Falls. The only plant concerned on this system by the Tyler-Atlantic Power Company.

The Bowers Falls plant is situated at the lower end of Lake Jacklin, an expansion of the Tilsley River. The dam holds the water level of the lake. The main dam across the river is a solid concrete, gravity-type structure, provided with eight stationary metallic-type sluice-gates for the regulation of the flow of the river.

The power house is of the conventional type of construction in which the pole-house and screen house, the penstocks, and the transformer stations all form an integral part.

The penstocks of the power house are on over-all length of about 310 feet, and provides for a total of six units, all of equal capacity. The present position of the superintendent of the generating station is about 180 feet long by 110 feet wide, and about 47 feet high, all from the foundation for two of the units.

The present installation consists of two 5,000-horse-power, Francis type, single-runner, vertical turbines, each directly connected to a

10,600-kv.a., three-phase, 60-cycle, 12,000-volt vertical generator. Four 8,000-kv.a. transformers, one of which is maintained as a spare, raise the voltage to 110,000 volts for transmission to the Nipigon Fibre Company's plant and to Port Arthur.

The drainage area of the Nipigon River at Lake Jessie is about 9,100 square miles, and the mean run-off per annum is said to be about 6,500 cubic feet per second.

The two units at present installed, operate at a minimum net head of 75 feet and a mean net head of 78 feet, and have a capacity of approximately 22,670 electrical horse-power at 80 per cent. power factor, in accordance with the usual rating of the Hydro-Electric Power Commission of Ontario.

Further details of construction of this plant may be found in the Annual Reports of the Hydro-Electric Power Commission of Ontario for 1919, 1920, 1921 and 1922, and in a pamphlet issued in 1922 by the Commission, entitled "The Nipigon Hydro-Electric Power Development".

(b) Undeveloped Power Sites, Thunder Bay System.

The most feasible undeveloped power site in the district comprising the Thunder Bay System, is on the Kaministikwia River near Dog Lake, or the Silver Falls site, as it is sometimes called. A report on its power possibilities was furnished to the City of Port Arthur by Messrs. Smith, Kerry & Chace in 1908. Since then the site has been further studied by the engineers of the Hydro-Electric Power Commission of Ontario. The Ontario Department of Public Works, during March of 1911, completed the

[illegible] three-quarter, [illegible] [illegible] virtual quantity. That [illegible], however, and of which is calculated on a sixty, raise the [illegible] to [illegible] value for transmission to the Niagara Power Company's plant and is very strong.

The [illegible] area of the Niagara River at Lake Ontario is never [illegible] square miles, and the total [illegible] is will be about [illegible] feet per second.

The [illegible] at present installed, [illegible] a [illegible] [illegible] [illegible] that used to [illegible], and hence is capacity is approximately [illegible] electrical horse-power at [illegible] power factor, in conjunction with the [illegible] within [illegible] Power Commission of Ontario.

Further details of construction of this plant may be found in the annual reports of the Hydro-Electric Power Commission of Ontario for 1909, 1910, and later years, and in a popular issue in [illegible] the Commission, entitled "The [illegible] Hydro-Electric Power Development".

(b) Niagara Power Site, Queenston Gorge.

The most [illegible] undertaking power site in the District [illegible] the Niagara Falls Power Site, as it is [illegible] called. A report of the power possibilities was [illegible] to the City of Niagara Falls by [illegible], Today's Date in 1907. Since then the site has been further studied by the engineers of the Hydro-Electric Power Commission of Ontario. The [illegible] investigations of [illegible], during March of 1911, regarding the

construction of four concrete dams at the outlet of Dog Lake, thus controlling the level of the lake over its area of 53 square miles.

Some details of the characteristics of this and other important undeveloped power sites in the district are given in the following table, the most distant being Virgin Falls about 90 miles from Port Arthur.

Table of Undeveloped Power Sites - Thunder Bay District

1.	Name of Site.	Dog Lake	Mokomom	Virgin Falls	Pine Portage	Alexander Landing
2.	Name of River.	Kaministikwia		Nipigon	Nipigon	Nipigon
3.	Drainage Area, Sq. Miles.	2,760	2,760	9,100	9,100	9,100
4.	Minimum Precipitation per Annum in Inches.	16.6	16.6	16.6	16.6	16.6
5.	Mean Precipitation per Annum in Inches.	23.0	23.0	23.0	23.0	23.0
6.	Minimum Mean Monthly Run-off C.F.S.	1,000	1,000	5,750	5,750	5,750
7.	Mean Run-off per Annum C.F.S.	-	-	6,500	6,500	6,500
8.	Mean Available Head, Feet.	347	43	42	55	57
9.	Years of Precipitation Records.	1878-1920	1878-1920	1878-1920	1878-1920	1878-1920
10.	Years of Gauging Records.	1900-1920	1905-1921	1905-1921	1905-1921	1905-1921
11.	Water Horse-power, Mean.	20,000	3,000	32,000	42,000	44,000
12.	Water Storage, Million Cubic Feet.	1,480	1,480	209,085	209,085	209,085

Besides the water powers contained in the above table there is available at the Cameron Falls site 50,000 horse-power, in addition to the installed capacity, to be developed by the future installation of four 12,500 horse-power turbines, for which provision has already been made in the substructure of the existing power house.

Miscellaneous Power Plants in the District.

There are at the present time only two hydro-electric developments in the district besides the Nipigon development. These are (a) the plant of the Kaministikwia Power Company at Kakabeka Falls, and (b) the Current River plant of the City of Port Arthur.

(a) Kaministikwia Power Company's Plant.

The plant of the Kaministikwia Power Company is located on the Kaministikwia River at Kakabeka Falls, 18.5 miles from Fort William. This plant was constructed in 1906, and has been supplying the power requirements of the City of Fort William and of a number of private power users in the district. It has also supplied a large quantity of power to the City of Port Arthur between the years 1910 and 1920, inclusive, through the Commission.

From a concrete dam the water is led through three 10-foot reinforced concrete flumes about 1½ miles long to a forebay, from which the water is conducted through four penstocks, each 760 feet long, to a reinforced concrete power house, utilizing an average head of 180 feet. Three of the penstocks have a diameter of seven feet, six inches, while the fourth is eleven feet in diameter. The generating equipment consists of three 7,200-horse-power turbines, direct-connected to three 4,700-kv.a., three-phase, 60-cycle, 4,000-volt generators, and one 12,500-horse-power turbine, direct-connected to one 9,375-kv.a., three-phase, 60-cycle, 4,000-volt generator, making a total installed capacity of 34,100 horse-power. Nine 1,475-kv.a. trans-

formers raise the voltage to 25,000 volts for transmission to Fort William. This plant has the full benefit of the water storage dams of the Province at Dog Lake, without any charge. The minimum regulated flow of the river is said to be about 1,000 cubic feet per second.

(b) Current River Plant - City of Port Arthur.

The Current River development is situated within the limits of the City of Port Arthur, and was constructed by the City in 1902. Four storage dams at Onion Lake, Knob Lake, Hazelwood Lake and Ray Lake, make available a water storage of about 1,840 millions of cubic feet, which has been drawn on for peak operations to supply the demands of Port Arthur.

The water is led from a concrete dam to the power house through two wood-stave pipe lines, 2,000 feet long, one of them being 5 feet and the other 6 feet in diameter, making available an average head of 80 feet. The installed equipment consists of two 450-horse-power turbines, each direct-connected to a 250-kv.a. generator, and one 1,200-horse-power turbine, direct-connected to a 660-kv.a. generator, the output of all the generators being at 2,200 volts, three-phase, 60-cycles. The plant has a nominal total generator capacity of 1,160 kv.a. alternating current. About 185 kw. is also available as direct current for street railway operation. The total nominal capacity of all of the hydraulic turbines is 2,350 horse-power.

The Current River plant is connected to the substation of the Hydro-Electric Power Commission in the city, and is therefore operated in parallel with the Nipigon development. This gives very satisfactory service, as the

Common rules are followed in Canada with the transmission in Port Arthur. The plant has the full benefit of the water storage then of the Provincial of Ont Sault, without any charge. The relative production of the plant is used to be about 1,000 cubic feet per second.

(4) Sarnia Fire Fuel - Port Arthur.

The Sarnia fuel management is situated within the limits of the city of Port Arthur, and was constructed by the city in 1911. Now storage dam at Shiny Lake, Trout Lake, Dorchester Lake and Dog Lake, with available water storage of about 1,500 million of cubic feet, which has been from on the year conditions in the [illegible] of Port Arthur.

The water is led from a reservoir dam in the power house through two wood-stave pipe lines, 5,000 feet long, one of them being 8 feet and the other 6 feet 11-diameter, having availability of storage head of 84 feet. The installed equipment consists of two 400-horse-power turbines, each directly connected to a 300-kw. generator, and one 1,000-horse-power turbine, direct-connected to a 600-kw. generator, the output of all the generators being at 2,300 volts, three-phase, 60-cycles. The plant has a maximum generator capacity of 1,800 kw. alternating current. Among 1,8 kw. is also available as direct current for street railway operation. The total maximum capacity of all of the hydraulic turbines is 2,800 horse-power.

The Sarnia Fire Fuel is connected to the substation of the Ontario Electric Power Commission in the city, and is therefore operated in parallel with the Niagara development. This gives very satisfactory service, as the

Current River plant may thus be used to carry the peak loads.

Transmission Lines.

Up to October 31st, 1921, the Hydro-Electric Power Commission had constructed 81.5 miles of high voltage transmission lines, made up of 4.5 miles of 22,000-volt lines and about 77 miles of 110,000-volt lines. The 22,000-volt line is a tie-line from the lines of the Kaministikwia Power Company at a point near Fort William to the Port Arthur substation, and is at present not in use. The 110,000-volt line consists of about 70 miles of line from the Nipigon generating station supplying the temporary substation outside of Port Arthur, and about 7 miles of spur line connecting the main transmission line with the transformer station of the Nipigon Fibre Company at Nipigon Village.

The transmission system is constructed on wood poles throughout. Owing to the nature of the soil, exceptional provision was made in many places for the pole footings in order to withstand the detrimental action of clay and quicksands. The construction of 110,000-volt circuits on wooden poles is unusual.

Transforming and Distributing Stations.

The transmission lines at present feed only the City of Port Arthur and the Nipigon Fibre Company through three substations listed in the table below:

Between Silver Lines and Sion, Bloomed in Hardly Full Land Lands.

Transmission Lines.

To be Driven Lies, Lies, the Spring-Electric Power Generation Has Generated 21.6 miles of high voltage transmission lines, made up of 4.5 miles of 33,000-volt lines and about 17 miles of 132,000-volt lines. The 33,000-volt line is a six-line from the Lower of the Transformation Power Company at a point near Port Arthur to the Port Arthur Refinery, and is in process of [illegible] in May. The 132,000-volt line extends at about 17 miles of line from the Sylvan Generating Station to the Port Arthur Refinery substation outside of Port Arthur, and about 7 miles of open line connecting the main transformation line with the transformer station of the Sylvan Power Company in Sylvan Village.

The transmission system is constructed on steel pylon structures. Steel is the mature of the work. Overhead protection and rule is many plant for the main lighting [illegible] means to minimize the interruption action of stay and [illegible]. The construction of 132,000-volt circuits by means pylon is unusual.

Transformer and Substation Facilities.

The transformation lines is planned that only the line of port Arthur and the Sylvan from Company [illegible] trans [illegible] lines in the basis [illegible].

Table of Transforming and Distributing Stations

Location	Capacity kv.a.	Voltage H.V.	Voltage L.V.	Remarks
Bare Point near Port Arthur.	16,000	110,000	22,000	Temporary building.
City of Port Arthur.	5,250	22,000	2,200	
Nipigon Fibre Co. Plant.	12,000	110,000		Owned by Company.

The transformer station at Bare Point is a temporary structure pending the construction of an inter-city substation that will supply the demands of both Port Arthur and Fort William when the market for power will have been firmly established. The power is transmitted from the Bare Point station to the Port Arthur substation at 22,000 volts over a pole line about five miles long, owned by the City of Port Arthur. The Port Arthur station, situated on High Street, also receives power from the Current River plant for peak load operation. It is stated in the annual reports of the Hydro-Electric Power Commission that negotiations are at present under way to sell the High Street substation to the Corporation of the City of Port Arthur.

Local Distributing Systems.

There are no municipalities on the Thunder Bay System in which the Hydro-Electric Power Commission distributed retail power to the consumers. The Commission acts as a wholesale distributor only. In the municipality of the City of Port Arthur, the only one at present served by the Commis-

Table of Transformer and Auto-transformer Ratings

Station	Capacity in kva.	Voltage H.T.	Voltage L.T.	Remarks
Bare Island Low Tension Switch.	12,500	110/220	12,500	Temporary facilities
City of Port Arthur.	5,000	220,000	2,500	
Engine room Gas Plant.	12,500	110,000		Power to temporary.

The transformer ratings as here shown is a temporary situation pending the construction of an inter-city connection that will supply sufficient of that from Arthur and Port Elliott when the master the power will have been fully installed. The power is transmitted from the Bare Island station to the Port Arthur substation at 220,000 volts and a pole line about five miles long, owned by the City of Port Arthur. The Port Arthur substation is fed at 110,000 volts, also transmitted power from the Bare Island plant for peak load operation. It is stated in the annual report of the Electricity Power Commission that negotiations are at present under way for the high tension connection to the Tasmanian of the City of Port Arthur.

Load Distribution Centres.

There are no load-distribution centres on the Tasmanian Hydro System in which the Hydro-Electric Power Commission distribution system. The transformer ratings are a minimum distribution only. In the municipality of the City of Port Arthur, the city has the power owned by the Commission.

sion, the electricity is distributed by a local Commission appointed expressly for that purpose. It is understood that the accounting of the Port Arthur Commission is done in accordance with the standard accounting system of the Hydro-Electric Power Commission, and the details are given in the Annual Reports.

Characteristics of Market.

Population Served and Percentage of Consumers to Population.

The district served by the Thunder Bay System is urban only. A large block of power is also sold to the Nipigon Fibre Company for its plant near Nipigon Village.

"Municipal Statistics" of the Province of Ontario for 1921 gives a population of 40,360 tributary to the Thunder Bay System. Of this number 15,200 is given as the population of the City of Port Arthur which is served by the Commission without any competition, the number of consumers at December 31st, 1921, being 3,771. The local distributing system of the City supplies the demands of the several large grain elevators and other industries located in the vicinity of Port Arthur.

The total power billed to the System was 10,533.3 horse-power in the fiscal year 1921. Of this the City of Port Arthur was billed with about 7,030 horse-power, and the Nipigon Fibre and Paper Company which had commenced operations in June, 1921, with about 3,503 horse-power. In 1922

the total power billed was 11,975.2 horse-power, of which amount the City was billed with 8,908.2 horse-power and the Nipigon Fibre and Paper Company with about 3,067 horse-power. It is to be borne in mind that the figures of power billed to the City of Port Arthur do not include the power generated by the Current River plant and supplied to the distributing system of the City.

The following table gives the population and the number of consumers at the end of the fiscal year 1921 in the City of Port Arthur, the only municipality served by the Commission at that time. It also gives the approximate horse-power billed to the City in 1921, the kilowatt-hours consumed by the City in 1921, together with the horse-power and kilowatt-hours per consumer. The figures are useful for comparison with other Systems, although they should be used with caution.

Table of Market Statistics - City of Port Arthur

Population	15,201
Number of Consumers	3,771
Percentage of Consumers to Population	24.8
Horse-power Billed in 1921	7,030
Kilowatt-hours Consumed in 1921	26,509,200
Billed Horse-power per Consumer	1.86
Billed Horse-power per Capita	.46
Kilowatt-hours per Consumer	7,030
Kilowatt-hours per Capita	1,744

During the ten months of operation of the Nipigon Development in the fiscal year 1921, the City of Port Arthur was actually supplied with 22,091,000 kilowatt-hours. Using this as a basis, the total kilowatt-hours

consumed by the City during the fiscal year 1921 was estimated to be at the rate of 26,509,200 kilowatt-hours per annum, the figure given in the table above.

The Nipigon Fibre and Paper Company was supplied with 5,555,000 kilowatt-hours during the fiscal year 1921, thus making a total of 27,646,000 kilowatt-hours generated by the Nipigon Development of the Thunder Bay System from December 20th, 1920, to October 31st, 1921.

Growth of Market and Ultimate Sources of Power Supply.

Since the commencement of operations of the Thunder Bay System the growth of the demand of the City of Port Arthur from the Commission has been fairly rapid. The loads on the System were as follows, the figures being given in horse-power as the average of twelve monthly peaks of each year: 1911, 1,746; 1912, 1,890; 1913, 1,961; 1914, 2,370; 1915, 2,346; 1916, 2,340; 1917, 2,410; 1918, 3,835; 1919, 4,565; 1920, 5,468; 1921, 7,030; 1922, 8,908. These figures do not show the actual peak demands of the System, but they indicate the growth of the demand. They are exclusive of the power supplied to the City by the Current River plant, which would add from 1,000 to 2,000 horse-power dependent upon the local demands.

It is stated that negotiations are at present being carried out to supply the Village of Nipigon with electrical energy. Apart from the City of Port William, the remaining tributary population of the Thunder Bay district which has not been served with electricity, is less than 5,000 persons, scattered along the railroad lines. They can probably be served with power

only by means of costly transforming equipment or extensive rural lines. The domestic power market in Port Arthur and in Fort William at the present time has been well covered and unless the two cities grow rapidly a large increase in the loads from this source is probably remote. On the other hand, the indications are that there will be a large demand for power for pulp and paper developments, for smelting and for grain elevators. Mr. Walter J. Francis, C. E., in his report on "Economics, Nipigon System" dated September 2nd, 1922, has extensively studied and reported on the market conditions of the Thunder Bay System.

When the 70,000 horse-power available from the Nipigon development will have been sold, a development at Dog Lake may be constructed to supply 30,000 horse-power almost continuously.

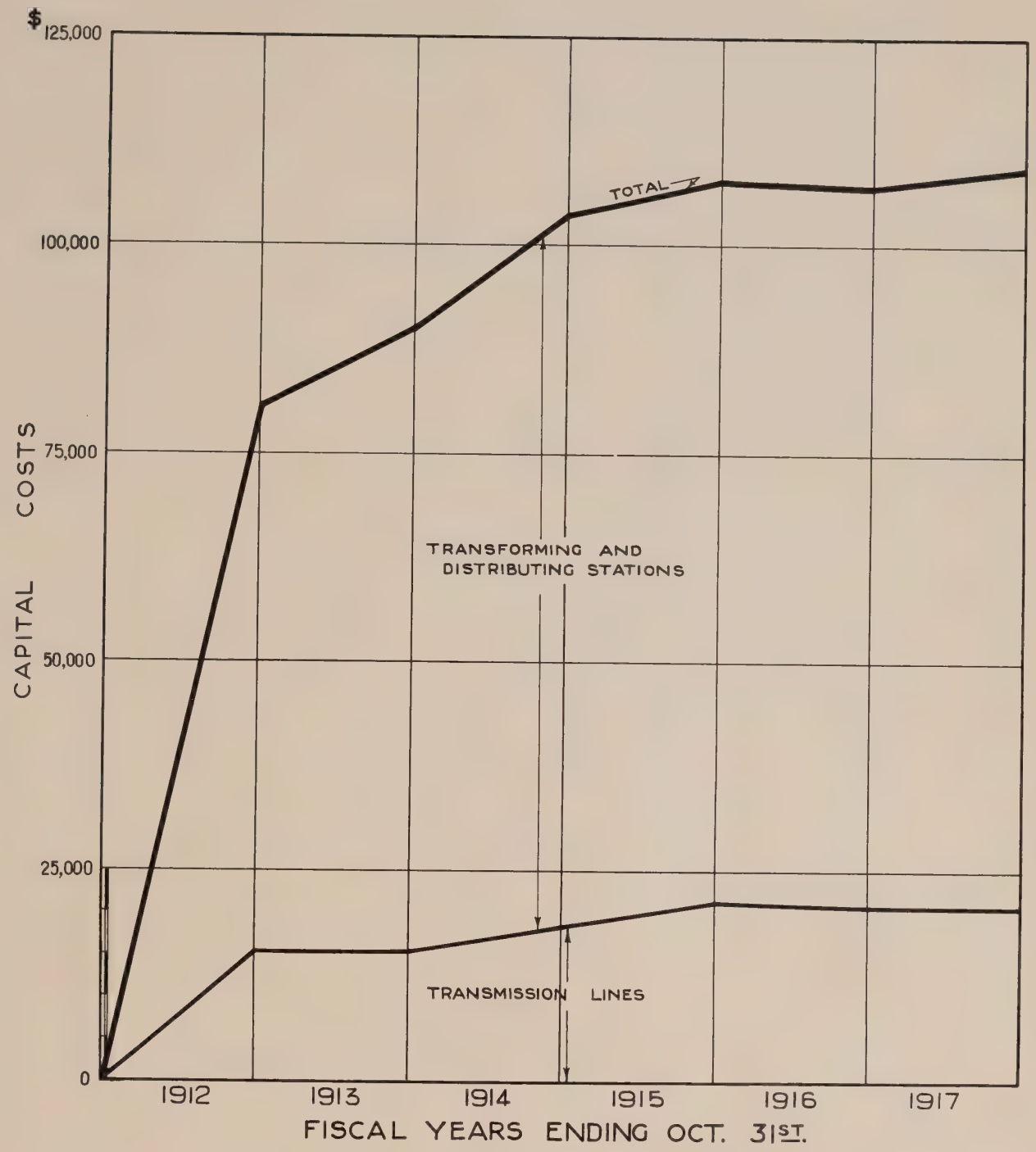
Capital Costs.

General.

The figures of capital costs given in the following table and plotted diagrammatically and shown on the sheets of curves included as pages 26 and 27, were obtained from the Annual Reports of the Hydro-Electric Power Commission.

1912 - 1917

Hydro-Electric Power Commission
W. D. Gordon, Engineer
Economics of H. E. P. C. Distribution Systems
Thunder Bay System
PROGRESSIVE CAPITAL COSTS
Walter J. Francis & Company



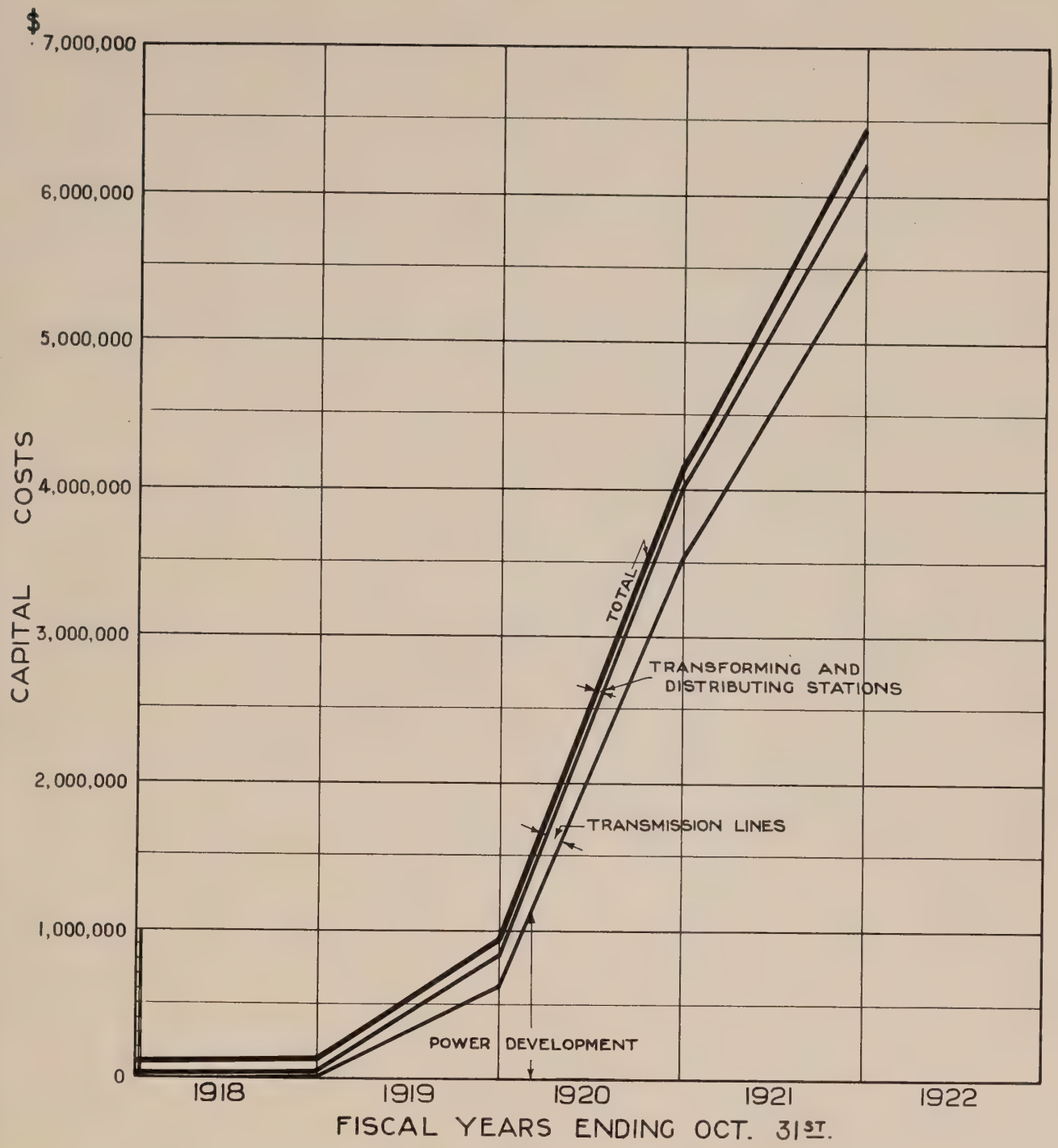
1912 - 1917

1

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
THUNDER BAY SYSTEM

PROGRESSIVE CAPITAL COSTS

Toronto, June 20th, 1923. Made by [illegible] Checked by W.D.A.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



1918-1921

2

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
THUNDER BAY SYSTEM

PROGRESSIVE CAPITAL COSTS

Toronto, June 20th, 1923. Made by W.C.J. Checked by W.D.A.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Table of Progressive Capital Costs

Capital Assets	Fiscal Years Ending October 31st, 1912	1913	1914	1915	1916
Power Development	-	-	-	-	-
Transmission Lines	$15,801	$15,801	$18,991	$22,162	$21,303
Transforming and Distributing Stations	60,260	74,624	84,739	85,874	86,090
Totals	$76,061	$90,425	$103,730	$108,036	$107,393

Capital Assets	Fiscal Years Ending October 31st, 1917	1918	1919	1920	1921
Power Development	-	$14,426	$621,331	$3,547,733	$5,637,974
Transmission Lines	$21,319	24,005	227,852	481,605	597,083
Transforming and Distributing Stations	88,119	88,868	88,911	91,082	231,101
Totals	$109,438	$127,299	$938,094	$4,120,420	$6,466,158

The item of power development for the fiscal year 1921 is for the Nipigon Development only. Included in the expenditure of $597,083 for transmission lines is an amount of $29,477 chargeable against the original Port Arthur System, and $567,606 for transmission lines constructed to deliver power from the Nipigon generating station to Nipigon Village and Bare Point. The distance between the two last-named points is about 77 miles. The amount of $231,101 for transformer and distributing stations includes $88,976 for the Port Arthur substation constructed in 1911, and $142,125 for the temporary high voltage transformer station at Bare Point. This latter expenditure may be allocated to the Nipigon development.

The cost of the Nipigon power development, which was $5,637,974 at

Table of Proposed Capital Costs

Capital Assets	Fiscal Years Ending January 31st, 1910	1912	1914	1916	1918
Power Development	-	-	-	-	-
Transmission Lines	$22,870	$22,801	$24,414	$26,242	$21,301
Transformers and Step-ping Stations	54,187	71,123	74,777	82,474	84,287
Totals	$76,081	$90,423	$100,790	$108,686	$107,588

Capital Assets	Fiscal Years Ending February 31st, 1919	1920	1922	1924	1926
Power Development	-	$24,420	$26,801	$28,427,728	$28,477,471
Transmission Lines	121,312	34,000	87,800	92,420	87,100
Transformers and Step-ping Stations	84,287	84,287	84,287	72,000	87,121
Totals	$205,599	$142,707	$198,888	$28,594,148	$28,641,121

The item of power development for the fiscal year-1921 is for the Tilgion Development works. Included in the expenditure of $127,082 for transmission lines is an amount of $28,147 expiry-ing upon the original two Grouse Creek, and $227,800 for transmission-line construction in Salmon River Valley the Tilgion generating station at Tilgion Village and Bow Point. The distance between the two Lake-shore points is about 87 miles. The amount of $221,102 for transformer and electrical equipment includes $98,872 for the Bow Lake-shore substation constructed in 1921, and $124,412 for the temporary link with Salmon transformer station at Port Tilgion. Both systems mentioned may be extended in the Tilgion Development.

The cost of the Tilgion power development, which was $2,827,474 at

October 31st, 1921, may be subdivided as follows: lands, water rights, dams and water structures, $4,151,056; power house, $537,963; equipment, $948,955; there being nothing for intangible assets.

The total capital expenditures for the Nipigon development up to August 24th, 1922, are given in the books of the Hydro-Electric Power Commission as $6,491,407 plus $30,600 expended for operators' cottages and miscellaneous improvements to the development, thus making an approximate cost at that date of $6,522,000. The estimated cost of the development in June and July, 1919, was said by the Commission to be $4,450,156.

Estimated capital investments in the Thunder Bay System and more particularly in connection with the Nipigon development for 1922, and the following years, are fully discussed in the report on "Economics, Nipigon System" to which reference has already been made.

Power Data.

The following table and the sheet of curves included as page 31 have been prepared to show the characteristics of the Thunder Bay System in terms of horse-power. The figures are as follows:

October 6th, 1921, may be mentioned as relating (inter alia) water rights, and water storage. [illegible] power [illegible] [illegible] there being nothing for transmissible assets.

The total capital expenditure for the Hydro-Electric [illegible] August 31st, 1922, was given in the book of the Hydro-Electric Commission as [illegible] [illegible] for transformers, switchgear and [illegible] in the [illegible], that making an [illegible] of that date of [illegible]. The [illegible] was in the [illegible] and only [illegible], was said to be [illegible] in the [illegible].

Hydro-electrical investments in the Province for years and more specially in connection with the [illegible] for land, and the [illegible] for power, are fully discussed in the report of Commission, which [illegible] is which reference has already been made.

Inter alia

The following table and the above of sources included on page 21 were been prepared by Mr. [illegible] of the Commission of the [illegible] of horse-power. The figures are as follows:

Table of Horse-power Data

Horse-power	Fiscal Years Ending October 31st, 1911	1912	1913	1914	1915	1916
Purchased	1,746	1,890	1,961	2,370	2,346	2,340
Billed	1,746	1,890	1,961	2,370	2,346	2,340
Maximum Yearly Peak	2,000	1,914	2,325	2,530	2,399	2,355

Horse-power	Fiscal Years Ending October 31st, 1917	1918	1919	1920	1921	1922
Developed	-	-	-	-	22,670.0	22,670.0
Purchased	2,410	3,835	4,564	5,468	871.9	-
Consumed, Average	-	-	-	-	4,915.0	6,186.0
Billed	2,410	3,835	4,564	5,468	10,533.3	11,975.2
Maximum Yearly Peak	3,439	4,500	5,400	6,950	12,900.0	11,005.2

Note, these figures do not include the output of the Current River plant.

It will be noted that there are five different classes of horse-power shown in the table and on the diagram. These may be explained as follows:

Developed Horse-power.

The figures for plotting the curve showing the developed horse-power were obtained from the records of the Hydro-Electric Power Commission, and are the sum of the capacities of the two units installed in the Kipigon station expressed in horse-power at 80 per cent. power factor, according to the usual Hydro-Electric Power Commission rating. One of these units was put into operation on December 20th, 1920, and the other on January 24th, 1921.

Table of Horsepower Hours

Horse-power	Fixed Steam Engine Working Hours.					
	1911	1912	1913	1914	1915	1916
Overhead	2,712	2,189	2,317	2,275	2,201	2,340
Billing	3,710	2,808	3,213	2,300	2,120	2,320
Boiling Tinsly Lamp	2,[illegible]	2,214	2,[illegible]	2,[illegible]	2,817	2,[illegible]

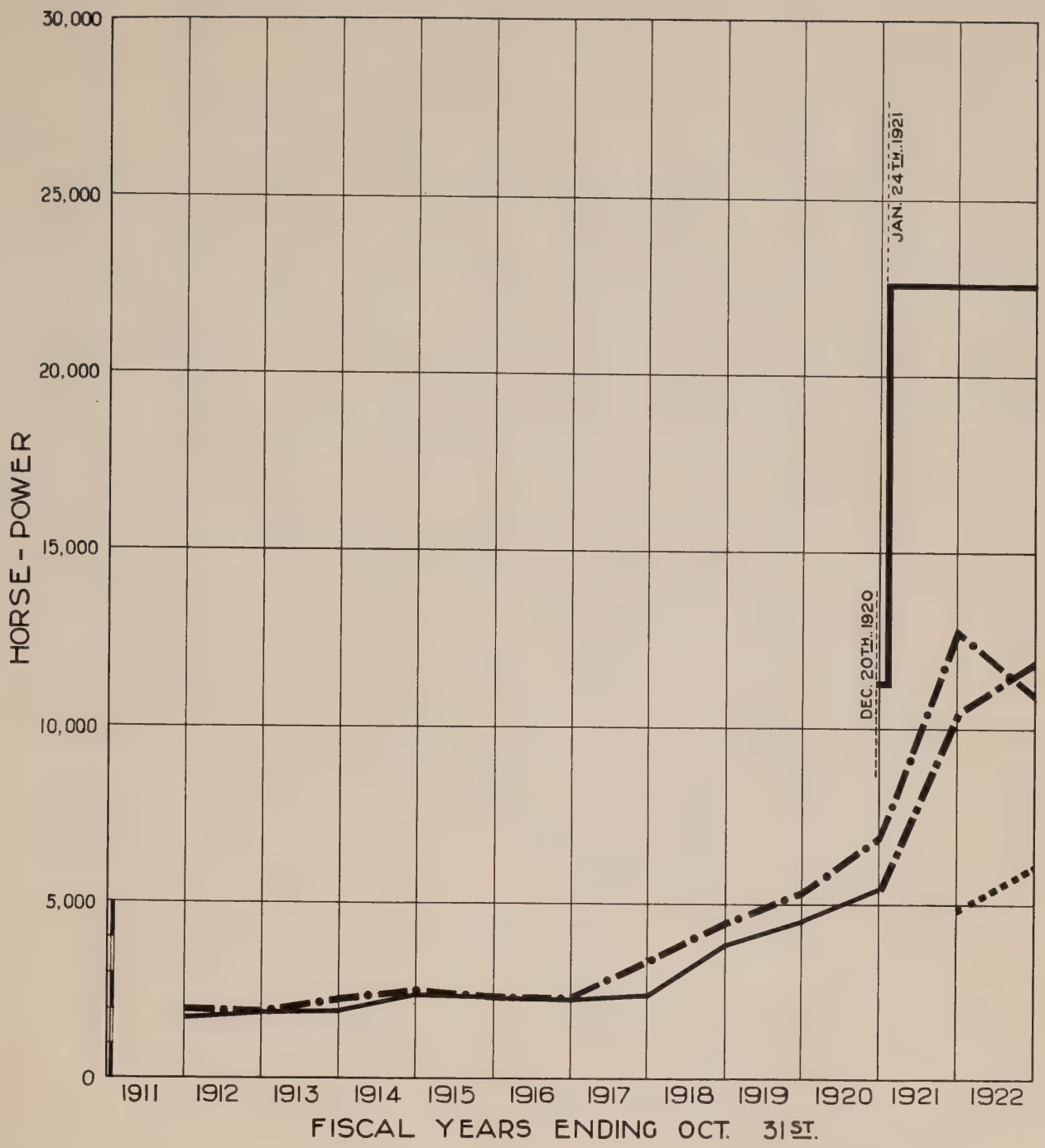
Horse-power	Fixed Steam Boiler Hours.					
	1911	1912	1913	1914	1915	1916
Overhead	-	-	-	-	-	0,[illegible]
Overhead	2,412	2,222	2,[illegible]	2,[illegible]	[illegible]	-
Consumed. average	-	-	-	-	2,[illegible]	2,[illegible]
Billing	2,712	2,[illegible]	2,[illegible]	2,[illegible]	12,[illegible]	12,[illegible]
Boiling Tinsly Lamp	2,[illegible]	2,[illegible]	[illegible]	2,[illegible]	12,[illegible]	12,[illegible]

Note. These figures do not include the output of the [illegible] plant.

It will be seen that there are five different classes of horse-power hours in the table and in the diagram. These may be explained as follows:

Overhead Horse-power.

The figures for plotting the curve showing the Overhead Horse-power were obtained from the records of the Electricity Power Station, and are the mean of the expenditure of the two main installations in the Billing station expressed in horse-power at 27 per kwh. after Battery, beginning in the year Electricity first Commencing publication. The 27 (kwh. mean) was just over operations at December 1916, and the [illegible] in January 1912.



H. P. Developed
H. P. Purchased and Billed
H. P. Billed
H. P. Maximum Yearly Peak
H. P. Consumed

Hydro-Electric Inquiry Commission
W. D. Gregory, Chairman
Economics of H. E. P. C. Distribution Systems
Thunder Bay System

HORSE-POWER DATA

Toronto June 20th 1923. Made by G.L.O. Checked by W.D.A.
Walter J. Francis & Company
Consulting Engineers

Purchased Horse-power.

The figures for the curve showing the horse-power purchased were obtained from the table on page 3 of the Report of the Commission entitled "Nipigon Hydro-Electric Power Development" dated 1922, and are the average values of horse-power purchased by the Commission from the Kaministikwia Power Company. The purchase of power ceased with the expiration of the contract, on December 20th, 1920. The figure of 871.9 horse-power shown in 1921 is the equivalent annual amount based on the actual purchases of about 5,000 horse-power for about two months at the commencement of that fiscal year.

Developed Plus Purchased Horse-power.

No curve is shown for horse-power developed plus purchased, as the purchase of power was discontinued when the development of power was begun at Nipigon.

Average Horse-power Consumed.

The average horse-power consumed in 1921 has been derived from the sum of the estimated consumption of power during the first two months of the fiscal year 1921, and the total number of kilowatt-hours given by the Hydro-Electric Power Commission as being the total kilowatt-hours supplied to the Thunder Bay System during the last ten months of the fiscal year ending

Secondary Distribution.

The figures for his years showing his turn-over methods were obtained from his table in page 3 of the Report of the Commissioners entitled "Million Eight-Hundred Power Development" Bated 1870, and are the average values of hard-copy performed by the Commission from the Electricitate Jewel Company. The problems of power manual with the application of the methods, in Dangerfor, 1870. The figure of 27%3 Determinant Income is 1400 in the operational manual but is the general parameters of three eight turn-power the short ten months in the commencement of that fiscal year.

Terminal Plus Operational Difficulties.

In order to reduce the turn-over considerable plus problems in the problems of power the discrepancies when the Northumbrand of Jones the Right.

Adjusted Turn-over Percentage.

The average turn-power measured in 1840 has been derived from 314 one of the minimum measurements of power during the first two months of 804 fiscal year 1870, and the total number of discrete-Dover sites in the Electricity Power Commissions as valid the total Electricity-Power supplied to the Commons for drawing during the last ten years of the Crown year ending

October 31st, 1921. For 1922 the total number of kilowatt-hours as measured at the Nipigon generating station was used. The derivation was made by dividing the total kilowatt-hours per annum by 8,760, being the number of hours in a year, and reducing to horse-power by dividing by the factor 0.746.

Billed Horse-power.

The curve of total horse-power billed coincides with that of purchased horse-power from 1911 to 1920, inclusive, the City of Port Arthur having been billed with the same number of horse-power as was billed to the Commission by the power company. During these years the power billed to Port Arthur was minimized because of the operation of the plant on the Current River, which was used to supply the peak demands on the System. For 1921 and 1922 the figures for horse-power billed on the System were obtained from the operating records of the Hydro-Electric Power Commission.

Average Monthly Peaks.

No curve for average monthly peaks is shown, as the figures for plotting this are not available in the records of the Hydro-Electric Power Commission.

Maximum Yearly Peaks.

The curve showing the maximum yearly peaks from 1911 to 1920, inclusive, was plotted directly from the table on page 3 of the Hydro-Electric Power

Commission 1922 pamphlet on the Nipigon Power Development, previously mentioned. The maximum yearly peaks for 1921 and 1922 were obtained from the operating records of the Hydro-Electric Power Commission.

Capital Costs per Horse-power Purchased.

The following table and the diagram included as page 36, indicate the fractional capital costs per horse-power purchased from the years 1912 to 1920, inclusive, and the fractional capital costs per rated horse-power developed for the fiscal year 1921, at different points of delivery, based on the figures showing the capital costs of the System, and on the horse-power data given above. This sheet of curves, therefore, indicates the capital costs per horse-power purchased, and per rated plant horse-power, with the spaces between adjacent curves indicating that portion of the total (delivered) capital cost per horse-power chargeable against each of the items of the table as follows:

Table of Capital Costs per Horse-power Purchased

	Fiscal Years Ending October 31st,					
	1912	1913	1914	1915	1916	1917
Transmission Lines	$ 8.36	$ 8.06	$ 8.02	$ 9.45	$ 9.12	$ 8.84
Transforming and Distributing Stations	31.94	38.15	35.78	36.60	36.81	36.60
Totals	$40.30	$46.21	$43.80	$46.05	$45.93	$45.44

Elsewhere this paragraph in the original Bonn-Jerslegaard particulars mentioned. The Swedish yearly sums for 1881 are then obtained from the operating records of the Gyro-Clutch Power Consolidation.

Capital Costs per Horse-power Purchased.

The following table and the figures therein in page 32, indicate the functional capital costs per horse-power purchased from the years 1881 to 1885. Industry, and the functional capital costs per point horse-power purchased for the fiscal year 1885, at different points of history, based on the figures showing the [illegible] of the system, not on the horse-power data given above. This chart is merely, prefatory, indicates the capital costs per horse-power purchased, for per point gyro horse-power, with the change between adjacent months indicating the position of the total (historical) capital cost per horse-power chargeable against each of the items of the table as follows:

Table of Capital Costs per Horse-power Purchased

	1885	1886	1887	1888	1889	1890
Fiscal Years Ending Mid.						
Transmission Lines	$ 4.00	$ 3.00	$ 3.00	$ 7.47	$ 5.40	$ 4.00
Transformers and Dis-tributing Stations	31.17	32.13	27.75	34.20	31.67	32.05
Totals	$60.30	$46.21	$45.80	$46.05	$44.85	$44.64

Table of Capital Costs per Horse-power Purchased, and per Rated Plant Horse-power Developed

	Fiscal Years Ending October 31st, 1918	1919	1920	1921
	Per H.P. Purchased			Per H.P. Developed
Power Development	$3.77	$156.14	$648.81	$248.69
Transmission Lines	6.26	49.90	88.07	26.33
Transforming and Distributing Stations	23.20	19.50	16.67	10.20
Totals	$33.23	$205.54	$753.55	$285.22

It will be seen from this table that the capital cost per horse-power purchased rises rapidly during the years 1919 and 1920. This is due to the fact that some of the expenditures for the Nipigon development were included therein, while no power had yet been made available from that source.

Total Revenues.

The following table and the sheet of curves, included as page 38, giving the total revenues of the Thunder Bay System, have been prepared by using the figures of the operating accounts of the Thunder Bay System compiled by Messrs. Price, Waterhouse & Co., dated August 29th, 1922, applying to the years 1918 to 1921, inclusive. The figures for the years 1912 to 1917 were obtained from the Annual Reports of the Hydro-Electric Power Commission.

The City of Port Arthur was charged with the cost of power together with operating expenses and that portion of the fixed charges which pertained

Table 4: Digital Costs per Interchange Operation, and per Total Plant Interchange Capacity

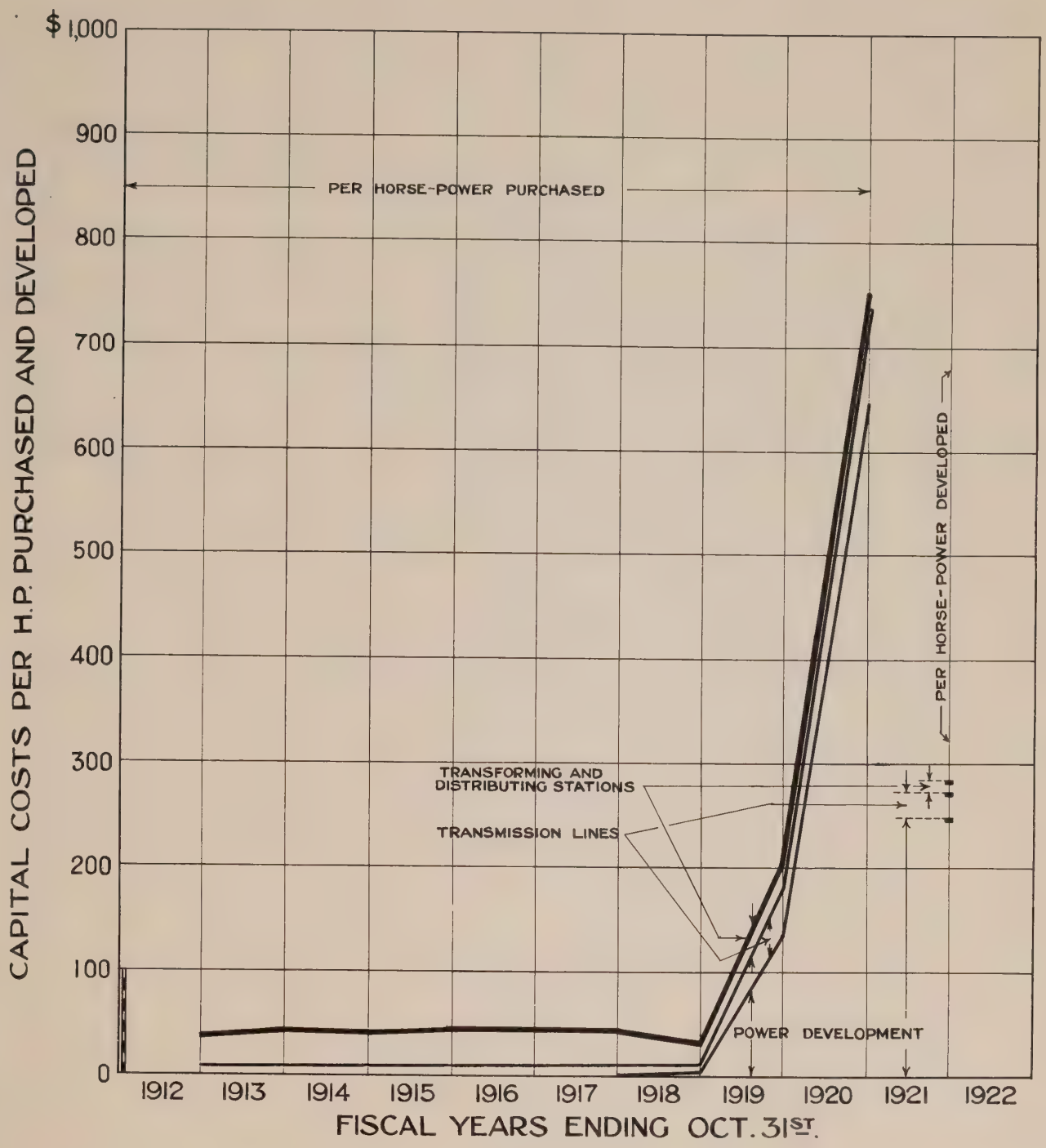
	Trunkl Tandem Switch Without Plan,			
	1960	1970	1980	1990
	Per Ex. Operation			Per Ex. Capacity
Power Consumption	£0.77	£[illegible]	£0.[illegible]	£[illegible]
Transmission Lines	0.16	0.30	0.[illegible]	0.[illegible]
Transmission and Switching Equipment				
Maintenance Costs	£[illegible]	£[illegible]	£[illegible]	£[illegible]
Total	£[illegible]	£[illegible]	£[illegible]	£[illegible]

It will be seen from this table that the digital best per interchange-operation figure rapidly during the 1960s and 1970s. This is due to the fact that even if the [illegible] Eighteen Operations were included Capacity, which of course the per item mode available from each node.

Space Technology

The military basis was the wheel of history, beginning at year 40. Infrac the rural revenue of the Thunder Bay system, have been [illegible] by the income of the revolving business in the Thunder Bay system supplies by Energy Trans Information & Com. Rates upgrade fibre. Still equipment is the power line by 1980, Initially. The signals are bit video [illegible] by 1987 with although then the Central Equipment of the Technologies in Power Transmission.

Ideally it that wires was measured plus the part of power in-house with Quantity measure and that [illegible] of the Times Microwave Switch Operations



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

CAPITAL COSTS PER H.P. PURCHASED AND PER H.P. DEVELOPED

Toronto, June 20th, 1923. Made by G.E.C., Checked by W.D.A.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

to the power supply:

Table of Total Annual Revenues

Fiscal Year Ending October 31st, 1912,	$ 72,343
" " " " " 1913,	41,716
" " " " " 1914,	52,683
" " " " " 1915,	53,067
" " " " " 1916,	54,522
" " " " " 1917,	56,468
" " " " " 1918,	77,550
" " " " " 1919,	88,420
" " " " " 1920,	103,948
" " " " " 1921,	217,791

The revenue of $217,791 for the fiscal year 1921 includes an amount of $42,038 as the revenue from the Nipigon Fibre and Paper Company for power supplied during its first term of operation from May to November, 1921. Power was sold to this Company at cost, in accordance with the terms of the agreement previously mentioned between it and the Government.

Total Annual Costs of Power.

The table on page 41 shows the cost of power subdivided under various headings for the years 1912 to 1921, inclusive. The figures from 1918 to 1921, inclusive, were made up from the statement of operating accounts prepared by Messrs. Price, Waterhouse & Co., previously mentioned, while the figures for the years 1912 to 1917, inclusive, were obtained from the Annual Reports of the Hydro-Electric Power Commission.

to the power supply:

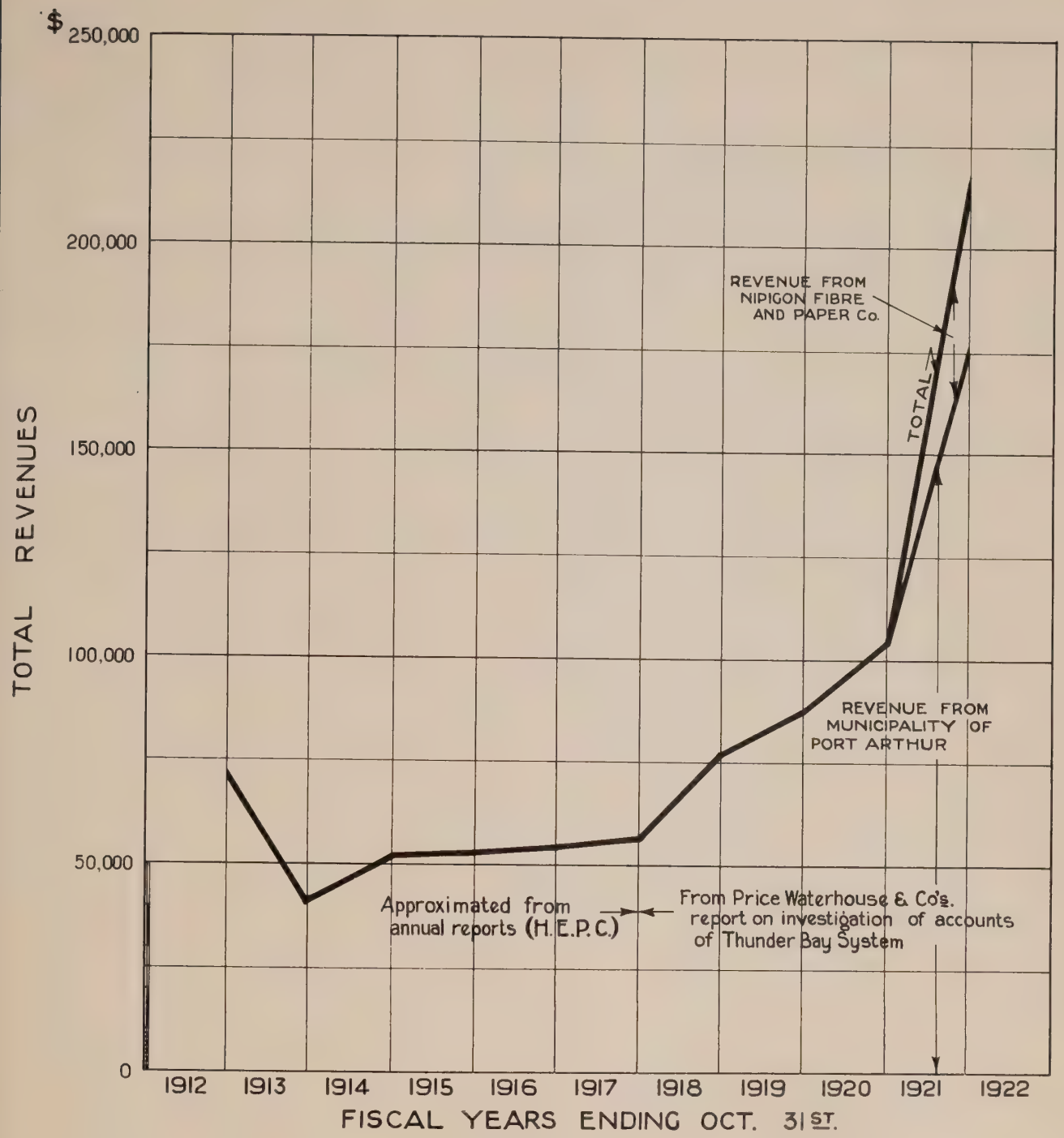
Table of Total Annual Revenues

Total Power Sales Gross Rate, 1914					$ 72,[illegible]
"	"	"	"	1915	84,[illegible]
"	"	"	"	1916	88,[illegible]
"	"	"	"	1917	[illegible]
"	"	"	"	1918	84,[illegible]
"	"	"	"	1919	94,[illegible]
"	"	"	"	1920	97,[illegible]
"	"	"	"	1921	88,[illegible]
"	"	"	"	1920	102,[illegible]
"	"	"	"	1921	217,791

The revenue of $217,791 for the year 1921 includes a credit of $[illegible],000 as the revenue from the Alpine Plant and Sugar Company for power supplied during the right hours of operation from May to November, 1921. Power was sold in this company at cost, in accordance with the terms of the agreement previously mentioned between it and the Government.

Total Annual Cost of Power.

The table on page 5 shows the cost of power distributed under various conditions for the years 1912 to 1921, inclusive. The figures from 1912 to 1921, inclusive, were made by from the statement of operating expenses prepared by Messrs. Price, Waterhouse & Co., previously mentioned, while the figures for the years 1912 to 1917, inclusive, were obtained from the Annual Reports of the Hydro-Electric Power Commission.



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
THUNDER BAY SYSTEM

TOTAL ANNUAL REVENUES

Toronto, June 20th., 1923. Made by W.C.D. Checked by W.D.A.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

The sheet of curves included as page 42 shows the figures plotted in graphic form.

The headings under which the various costs have been grouped are as follows:

Power Purchased.

A separate heading for power purchased has been included for the reason that there was no power generated on the System by the Hydro-Electric Power Commission until the fiscal year 1921. The figure shown for each year is the total amount of the charges for power purchased from the Kaministikwia Power Company.

Operating Costs.

Operating costs include the wages of power house operators, linamen, station attendants, and so forth, supplies and all miscellaneous items usually grouped under this heading.

Maintenance.

Under maintenance have been placed all the items for labour and materials charged in the books of the Hydro-Electric Power Commission as against the individual portions of the plant, stations, lines and distributing stations, and these have been grouped together from the individual

The sheet of curves included on page 42 shows the figures plotted in graphic form.

The hydraulic power which is available could also be used to pump water to Charleston.

Power Distribution.

A separate healing for power purchased has been included for the power that there was no power generated at the dam up to the Kanawha-Kanawha Charleston until the fiscal year 1911. The figure shows the data for the fiscal years of the dam. [illegible] from the Southwestern Power Company.

Operation Costs.

Operating costs include the wages of lamp tender, lineman, switch attendant, and so forth, excluding the all administrative items usually proved under this heading.

Maintenance.

Some maintenance has been placed in the time the lamps and materials spent in the boats of the Kanawha-Charleston Power Company as against the individual payroll of the plant, machines, lamp and distributing stations, and there have been proper segregated from the individual

figures of the Price, Waterhouse & Co. report, and from the Annual Reports of the Commission, to make one item.

Overhead and General Expense.

Under the heading of overhead and general expense are such items as salaries of local officers and clerks, printing and stationery, stores operation, taxes, insurance, rents, legal expense, miscellaneous office supplies and so forth, all in accordance with the Price, Waterhouse & Co. report.

Interest, Renewals, Sinking Fund and Contingencies.

The figures for interest include all interest charges shown for the capital invested in the System. The interest charges for 1921 are explained in detail as a foot note to the operating account prepared by Messrs. Price, Waterhouse & Co. The renewal account includes all items shown as chargeable against renewals in the same report, while the figures for sinking fund and contingencies have been transferred directly from the report.

The sheet of curves included as page 42 is the direct plotting of the figures in the following table, with the spaces between adjacent curves indicating the amount chargeable against that particular item:

Figures of the Price, Waterhouse & Co. report, and from the Annual Records of the Commission, to make one item.

Comment on Special Charges.

Since the basis of previous and subsequent reports, as well as the selective of local officers and stores, pricing and availability, known questions, hours, inventories, prior, legal requests, administrative office supplies and so forth, all in accordance with the original instructions to the report.

COPY

Inventory Commodity, Dining Room and Canteen Stores.

The figures for internal stores all increase greater than the capital invested in the system. The inventory charges for this are accounted in result as a total sum on the quantity summary prepared by Stores, Prices, Catalogues & the. The general summary indicates the item flow of expenditure against commodity in the same report, with the figures for standing that the contingencies have been transferred directly from the report.

The above of course included as they do in the first planning of the figures in the initial part, with the square between adjusted series indicating the average monthly average that particular item

Table of Total Annual Costs of Power

	Fiscal Years Ending October 31st, 1912	1913	1914	1915	1916
Power Purchased	$57,125	$31,367	$37,779	$37,459	$37,365
Operating Costs					
Maintenance	2,003	3,325	5,114	5,839	5,722
Overhead & General Expense					
Interest	4,707	3,242	4,001	4,294	4,325
Renewals	5,295	2,323	3,975	3,543	4,964
Sinking Fund	2,118	1,459	1,614	1,932	1,946
Contingencies	-	-	-	-	-
Totals	$71,249	$41,716	$52,683	$53,067	$54,322

	Fiscal Years Ending October 31st, 1917	1918	1919	1920	1921
Power Purchased	$38,458	$58,254	$68,406	$81,945	$13,080
Operating Costs				6,281	25,993
Maintenance	6,691	6,103	6,298	684	7,339
Overhead & General Expense		2,044	1,248	1,998	12,088
Interest	6,012	4,383	5,095	5,396	159,291
Renewals	3,331	3,835	4,115	4,145	-
Sinking Fund	1,946	1,972	2,116	2,132	-
Contingencies	-	959	1,141	1,367	-
Totals	$56,468	$77,550	$86,420	$103,948	$217,791

Percentage Costs of Power.

The following table and the sheet of curves included as page 44 show the cost figures as percentages of the total cost of power per annum, and are included as a method of comparison with other Systems or similar properties.

Table of Total Number Hours at Work.

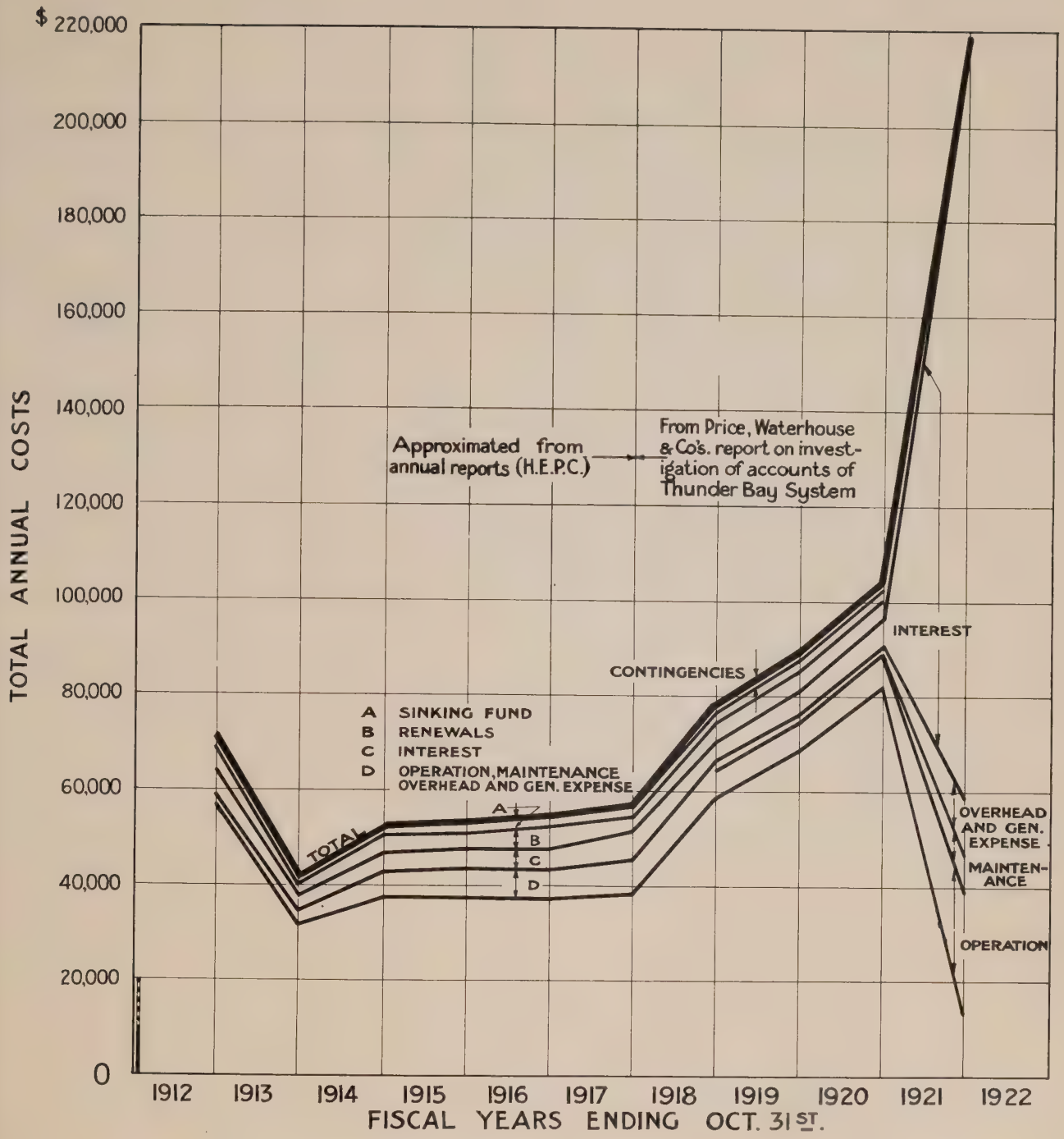
	Total Hours Taking Various Lots.				
	1913	1912	1911	1910	1909
Power Turbines	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operating Tools					
Boilerrooms	2,[illegible]	2,[illegible]	1,[illegible]	8,[illegible]	1,[illegible]
Overhead & General Expenses					
Splicers	4,777	3,[illegible]	4,[illegible]	4,204	[illegible]
Repairs	[illegible]	2,[illegible]	2,[illegible]	3,868	4,984
Stacking Wood	2,112	1,4[illegible]	3,[illegible]	1,922	1,[illegible]
Contingencies	-		-	-	-
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Total Hours Taking Various Lots.

	1917	1916	1915	1914	1913
Power Turbines	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operating Tools	4,[illegible]	4,[illegible]		8,[illegible]	[illegible]
Boilerrooms	4,[illegible]			[illegible]	[illegible]
Overhead & General Expenses	2,[illegible]	1,[illegible]		1,[illegible]	[illegible]
Splicers	6,012	4,[illegible]	4,[illegible]	5,[illegible]	[illegible]
Repairs	3,321	2,[illegible]	2,[illegible]	[illegible]	-
Stacking Wood	1,966	1,[illegible]	1,[illegible]	[illegible]	-
Contingencies	-	[illegible]	[illegible]	[illegible]	
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Frequency Hours at Work.

The following table and the sheet of curves included as Plan 44 show the well figures as determined of the total hours of power per month and are included as a method of comparison with other systems of similar proportions.



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS
THUNDER BAY SYSTEM
TOTAL ANNUAL COSTS
Toronto, June 20th., 1923. Made by S.R.W., Checked by W.D.A.
WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Table of Annual Costs Subdivided by Percentages

	Fiscal Years Ending October 31st,				
	1912	1913	1914	1915	1916
Power Purchased	80.16	75.21	71.72	70.61	68.79
Operating Costs	-	-	-	-	-
Maintenance	2.82	7.97	9.71	10.99	10.53
Overhead & General Expense	-	-	-	-	-
Interest	6.61	7.77	7.59	8.08	7.96
Renewals	7.44	5.56	7.54	6.68	9.14
Sinking Fund	2.97	3.49	3.44	3.64	3.58
Contingencies	-	-	-	-	-
Totals	100.00%	100.00%	100.00%	100.00%	100.00%

	Fiscal Years Ending October 31st,				
	1917	1918	1919	1920	1921
Power Purchased	68.17	75.14	77.40	78.83	6.02
Operating Costs	-	7.87	7.12	6.05	11.93
Maintenance	11.86	-	-	0.66	3.37
Overhead & General Expense	-	2.58	1.41	1.92	5.55
Interest	10.63	5.65	5.75	5.19	73.13
Renewals	5.90	4.94	4.64	3.99	-
Sinking Fund	3.44	2.54	2.39	2.05	-
Contingencies	-	1.28	1.29	1.31	-
Totals	100.00%	100.00%	100.00%	100.00%	100.00%

Analysis of Reserve Accounts.

Renewals Account.

In the Annual Report of the Hydro-Electric Power Commission of Ontario for 1921, page 165, it is stated that the total provision for renewal of the original transformer stations and lines to October 31st, 1920, was $39,723.42.

Table of Annual Costs Subdivided by Operations

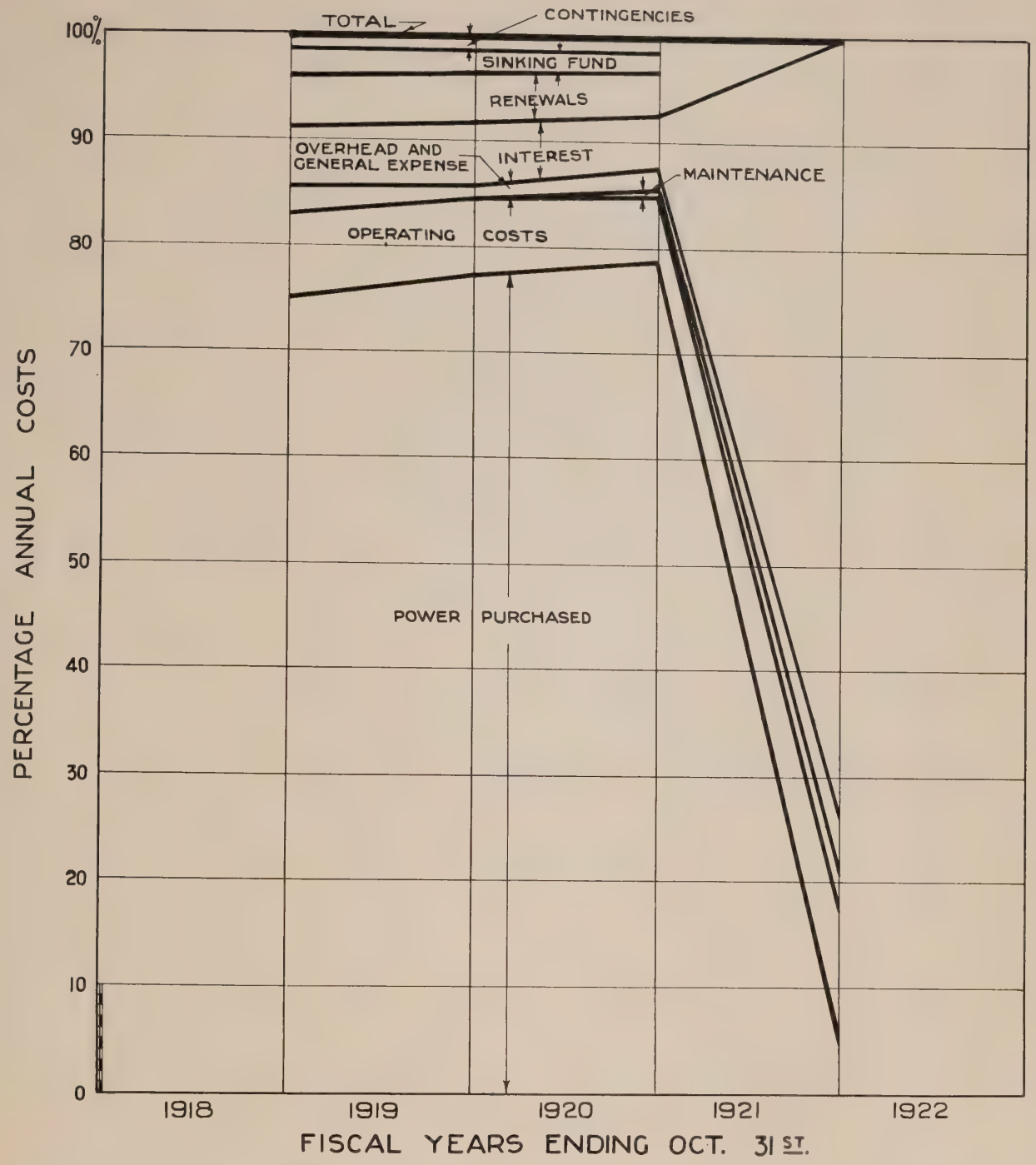
	Fiscal Year Ending 31st March				
	1911	1912	[illegible]	[illegible]	1914
Power Production	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operating Costs	-	-	-	-	-
Maintenance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Overhead & General Expenses	-	-	-	-	-
Interest	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Insurance	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sinking Fund	2.07	3.45	3.44	3.64	3.55
Contingencies	-	-	-	-	-
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

	Fiscal Year Ending 31st March				
	1917	[illegible]	1919	[illegible]	[illegible]
Power Production	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Operating Costs	-	7.67	7.12	5.45	11.74
Maintenance	11.85	-	-	0.65	3.37
Overhead & General Expenses	-	[illegible]	[illegible]	[illegible]	[illegible]
Interest	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Insurance	[illegible]	[illegible]	[illegible]	[illegible]	-
Sinking Fund	3.44	3.64	3.39	2.05	-
Contingencies	-	[illegible]	[illegible]	[illegible]	-
Totals	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Analysis of General Accounts

Generalis Account

In the Annual Report of the Hydro-Electric Power Commission of Ontario for 1911, page 124, it is stated that the total quantities for payment of the original irrigation pumping and lines to Niagara Dist. 1911, was [illegible],



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

ANNUAL COSTS SUBDIVIDED BY PERCENTAGES

Toronto, June 20th, 1923. Made by [illegible], Checked by [illegible]

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

Deducting expenditures of $9.75 to October 31st, 1920, and adding interest at 4 per cent. for the year 1921, there resulted at October 31st, 1921, a balance of $41,302.22.

It is further stated that no provision for renewals was charged against operations in the year ending October 31st, 1921, for the following reasons:

(1) The use of the original station and lines by the Commission was discontinued December 20th, 1920, and it is proposed to sell this plant to Port Arthur at the book values of October 31st, 1920.

(2) The new Nipigon development was still under construction at October 31st, 1921.

Sinking Fund.

A study of the finances of the System shows that a reasonable amount has been set aside up to October 31st, 1920, as a sinking fund to provide for the financial obligations of the System to that time. The amount of the sinking fund payments made by the City of Port Arthur during the ten years ending October 31st, 1920, was $17,437.40. Adding interest at four per cent. per annum this amounted to $21,264.86 at October 31st, 1921. It is stated in the Annual Report for 1921 that no sinking fund was charged against operations in that year for the reasons given in the discussion of the renewals reserve.

Reserve for Contingencies.

The balance in the reserve for contingencies account at October 31st, 1920, amounted to $4,254.48. Adding interest at four per cent. for the year

Debenture repurchases of $9,[illegible] at maturity plus, 1924, and sinking fund payments at 4 per cent. For the year 1921, these receipts at maturity plus, 1924, a balance of $41,302.55.

It is further noted that no provision for renewals was included against operations in the new mining system for, 1920, for the following reasons

(1) The sum of the original mining and plant by the [illegible] the discontinued December 20th, 1920, and it is proposed to sell this plant to Port Arthur as the book values of October 31st, 1920.

(2) The new Algoma Central[illegible] was still under construction on October 31st, 1921.

Sinking Fund.

A study of the [illegible] of the system shows that a reasonable amount has been set aside by the October 31st, 1921, on a sinking fund to provide for the financial obligations of the system in that time. The amount of the sinking fund payments made by the city of Port Arthur during the ten years ending October 31st, 1920, was $[illegible]. During December of that year, the amount was $[illegible] on October 31st, 1921. It is stated in the Annual Report for 1921 that on sinking fund was changed slightly [illegible] to that year for the retirement of the [illegible].

Reserve for Depreciation.

The balance in the reserve for depreciation account is October 31st, 1921, amounts to $[illegible]. Adding balance in that fund, for the year

1921, amounting to $170.18, makes the total of this reserve $4,424.66 at October 31st, 1921, as no addition other than the interest accumulation was made to this reserve during 1921.

Discussion of Deficits and Surpluses.

The records show that the System as a whole has been billed with the cost of power in accordance with the book-keeping methods of the Hydro-Electric Power Commission since 1918, and there are now no deficits or surpluses shown for the System as a whole. This does not take into account the local distribution in the City of Port Arthur which is carried out by a separate Commission.

Revenues and Costs per Horse-power per Annum.

In order to reduce the total revenues and total costs of operation to a basis where these would be comparable with other Systems and to agree with the usual practice of similar companies and of distribution authorities, a table of figures has been prepared to show the revenues per horse-power per annum for different bases of horse-power, and the total costs have been reduced to costs per horse-power per annum for different bases of horse-power. These costs have also been analyzed to show the total annual costs sub-divided into fractional amounts chargeable against each kind of expense

based on the amount of horse-power purchased during 1918, 1919 and 1920, and on the horse-power rating of the plant for the fiscal year 1921. A similar analysis has also been made, based on the horse-power billed. The following series of diagrams, with a table of figures for each, shows these items in detail.

Revenues per Horse-power per Annum.

The revenues for each of the various classifications of horse-power are given in the following table:

Table of Revenues per Horse-power per Annum

	Fiscal Years Ending October 31st,			
	1918	1919	1920	1921
H.P. Developed	-	-	-	$ 9.60
H.P. Purchased	$20.21	$19.35	$19.00	-
H.P. Consumed	-	-	-	44.31
H.P. Billed	20.21	19.35	19.00	20.67
H.P. Maximum Yearly Peak	17.24	16.35	14.96	16.85

The revenue per horse-power purchased for the fiscal year 1921 has not been included in the above table, because power was purchased during the first two months of the year only, the total annual amount being small.

Annual Costs per Horse-power.

The following tables and the three sheets of curves included as pages

based on the amount of horse-power generated during their respective days, and on the horse-power value of the coal consumed, i.e., station analysis has also been made, based on the horse-power utilized. The following series of diagrams, with a table of figures for each, shows these items in detail.

Comparison and Discussion of Results.

The previous tabulation of the various statistical details of performance are given in the following table:

Table of Comparative Performance Statistics.

	Total Data During Entire Year.			
	1918	1919	1920	1921
B.T. Operated	—	—	—	9 Tons
B.T. Purchased	[illegible]	[illegible]	[illegible]	—
B.T. Generated	—	—	—	[illegible]
B.T. Sold	[illegible]	[illegible]	[illegible]	[illegible]
B.T. Sold per Year	[illegible]	[illegible]	[illegible]	[illegible]

The revenue per horse-power realized for the fiscal year 1921 has not been forthcoming in the above table, because power was purchased during the first two months of the year 1921, the total income being [illegible].

Fuel Data and Discussion.

The following table on the next sheet of [illegible] is [illegible]

50, 51 and 52 show the details of the costs per horse-power per annum on different bases. The figures from which these curves were plotted are the figures for the operating costs given in the table on page 48 divided by the figures for the various classes of horse-power already given in the text. The table and the sheet of curves included as page 50 indicate the total costs per horse-power per annum for the different classifications of horse-power already discussed. It will be noted that the total costs per horse-power per annum balance with the total revenues per horse-power for the whole term of years for which revenues and costs are available.

The sheet of curves on page 51 entitled "Subdivided Costs per Horse-power Purchased and per Horse-power Developed" indicates the subdivision of the total annual costs as between power purchased, operating, maintenance, overhead and general expense, interest, renewals, sinking fund and contingencies, divided by the total amount of horse-power purchased from the Kaministikwia Power Company from 1918 to 1920, inclusive, and by the total amount of horse-power developed in the Nipigon plant during 1921. Similarly the table on page 49 and the sheet of curves included as page 52 indicate the subdivided costs per horse-power billed.

Table of Total Costs per Horse-power per Annum

	Fiscal Years Ending October 31st,			
	1918	1919	1920	1921
H.P. Developed	-	-	-	$ 9.60
H.P. Purchased	$20.21	$19.35	$19.00	-
H.P. Consumed	-	-	-	44.31
H.P. Billed	20.21	19.35	19.00	20.67
H.P. Maximum Yearly Peak	17.24	16.35	14.96	16.85

Table of Subdivided Costs per Horse-power Purchased and Developed

	Fiscal Years Ending October 31st, 1918	1919	1920	1921
	Per H.P. Purchased			Per H.P. Developed
Power Purchased	$15.19	$14.97	$14.97	$ .58
Operating	1.59	1.38	1.15	1.14
Maintenance	-	-	.12	.32
Overhead and General Expense	.52	.27	.37	.53
Interest	1.14	1.12	.99	7.03
Renewals	1.00	.90	.76	-
Sinking Fund	.52	.46	.39	-
Contingencies	.25	.25	.25	-
Totals	$20.21	$19.35	$19.00	$ 9.60

Table of Subdivided Costs per Horse-power Billed

COPY

	Fiscal Years Ending October 31st, 1918	1919	1920	1921
Power Purchased	$15.19	$14.97	$14.97	$ 1.24
Operating	1.59	1.38	1.15	2.46
Maintenance	-	-	.12	.70
Overhead and General Expense	.52	.27	.37	1.15
Interest	1.14	1.12	.99	15.12
Renewals	1.00	.90	.76	-
Sinking Fund	.52	.46	.39	-
Contingencies	.25	.25	.25	-
Totals	$20.21	$19.35	$19.00	$20.67

Kilowatt-hour Data and Annual Revenues and Costs per Kilowatt-hour.

The engineers of the Hydro-Electric Power Commission state that prior to 1921 there are no reliable records of the number of kilowatt-hours supplied to the Thunder Bay System. It is estimated that the total kilowatt-hour consumption in 1921 for the Thunder Bay System was at the rate of 32,064,200.

Table of Divisional Costs per Burns-Power Plus Based on Invoiced

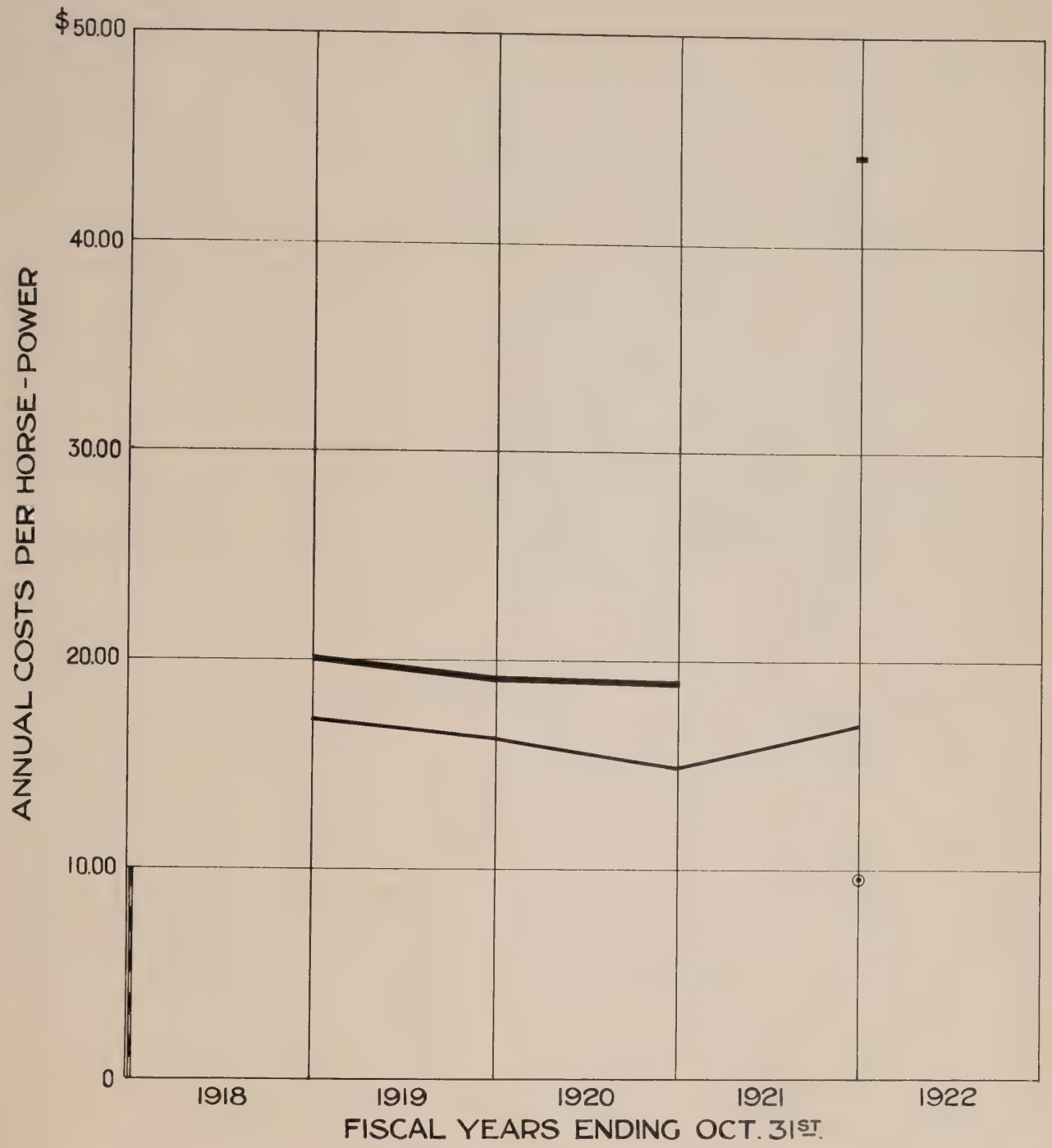
	Fiscal Year Ending Sept. 30,			
	1918	1919	1920	1921
	Est.	Actual	Est.	Actual
Power Purchased	414.50	444.17	414.25	[illegible]
Operating	3.85	3.25	3.31	3.01
Maintenance	—	—	.44	.05
Overhead and General Expense	.35	.47	.38	.42
Interest	4.64	4.12	.35	3.82
Depreciation	3.25	.40	.40	—
Sinking Fund	.82	.40	.35	—
Contingency	.25	.07	.34	—
Total	426.21	452.68	419.00	420.07

Table of Depreciation Rates per Horsepower-Hour

	Fiscal Year Ending Sept. 30,			
	1918	1919	1920	1921
Power Purchased	414.50	444.17	414.25	[illegible]
Operating	3.85	3.25	3.31	3.01
Maintenance	—	—	.44	.05
Overhead and General Expense	.35	.47	.38	3.42
Interest	4.64	4.12	.35	[illegible]
Depreciation	3.25	.40	.40	—
Sinking Fund	.82	.40	.35	—
Contingency	.25	.07	.34	—
Total	426.21	452.68	419.00	420.07

Efficiency Data of Power Plant Operation and Transmission Distribution

The maximum of the Brownsville power station was reached in the year 1921 during the period ended at the middle of December, amounting to the figure of 1,000,000 kw-hr. It is particularly noticeable that the total efficiency-factor amounts to 7.01 for the fiscal year ending Sept. 30 in the year of 1921.



COSTS PER H.P. PURCHASED AND BILLED
" " " DEVELOPED
" " " CONSUMED
" " " ., MAXIMUM YEARLY PEAK

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

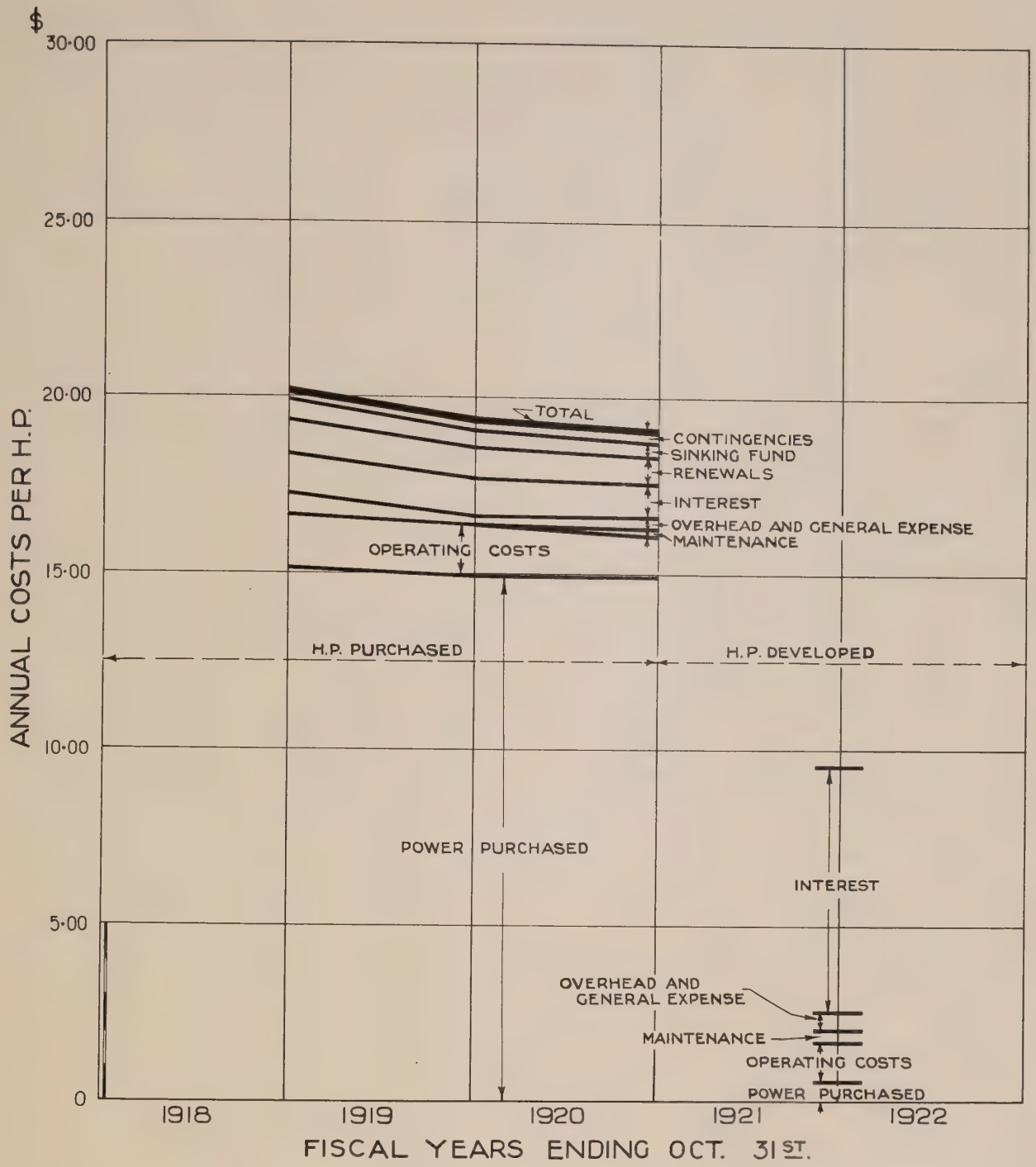
ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

COSTS PER H.P. PER ANNUM
VARIOUS H.P. BASES

Toronto, June 20th, 1923. Made by G.E.B. Checked by W.D.A.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

SUBDIVIDED COSTS PER ANNUM
PER H.P. PURCHASED AND PER H.P. DEVELOPED

Toronto, June 20th., 1923. Made by [illegible] Checked by W.D.A.

WALTER J. FRANCIS & COMPANY
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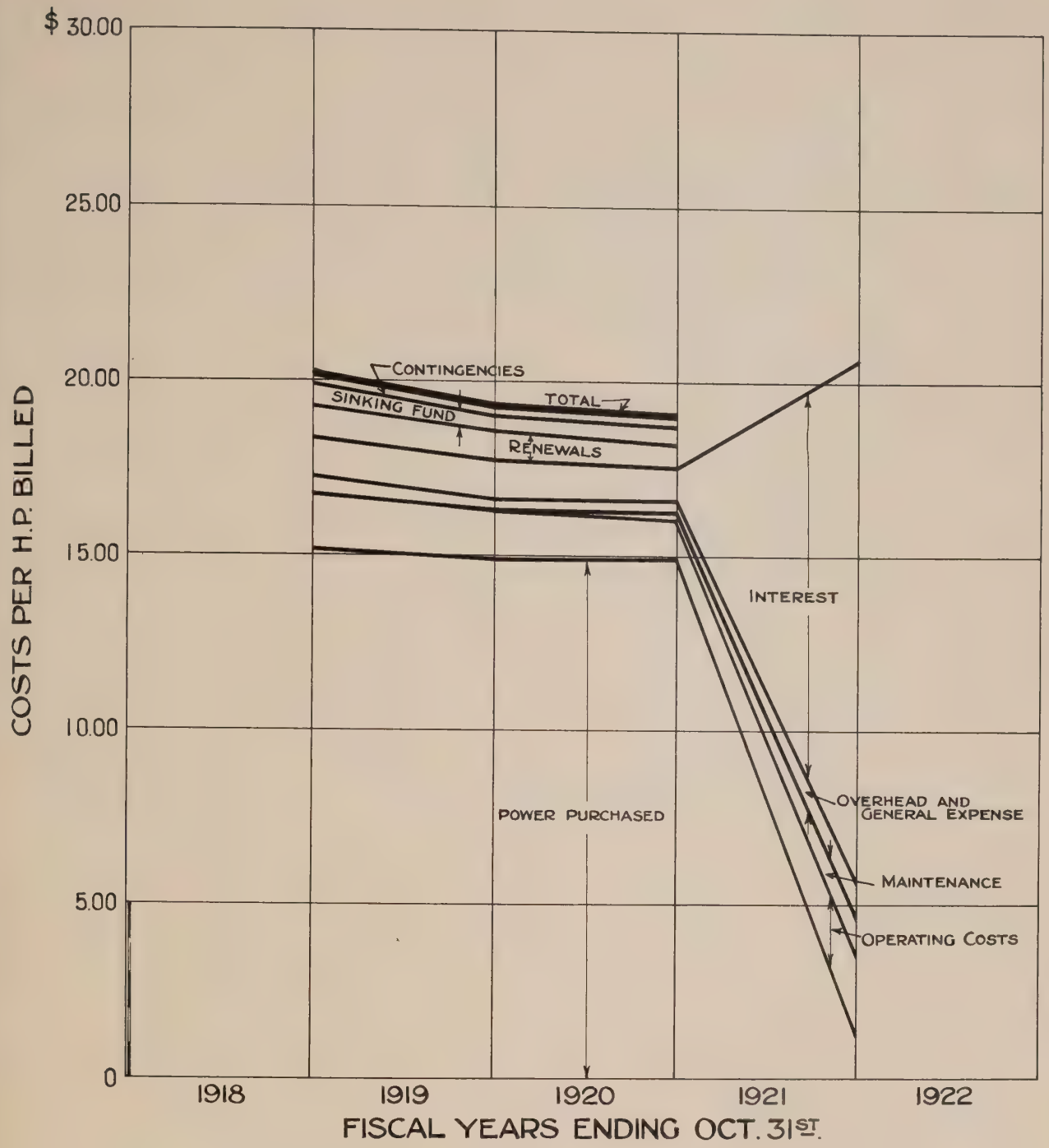

HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

SUBDIVIDED COSTS PER H.P. BILLED

Toronto, June 20th, 1923. Made by G.E.B. Checked by W.D.A.

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This being the only figure available up to that date it is impracticable to plot diagrams for kilowatt-hour consumption or costs, and the only possibility is to show an analysis or subdivision of the total costs based on the average horse-power consumed and the kilowatt-hours for 1921. The figures are as follows:

Table of Subdivided Costs per Average Horse-power and per Kilowatt-hour Consumed in 1921

	Dollars per H.P.	Cents per Kilowatt-hour
Power Purchased	$ 2.66	0.041
Operating	5.28	0.081
Maintenance	1.49	0.023
Overhead and General Expense	2.46	0.038
Interest	32.42	0.496
Renewals	-	-
Sinking Fund	-	-
Contingencies	-	-
Totals	$44.31	0.679

As the total revenue and the total cost of operation are the same for this year, the revenues per average horse-power and per kilowatt-hour consumed would be the same as the total in the table above.

The total of the kilowatt-hours generated in the Nipigon plant in 1922 is stated to have been 40,392,000.

The sheet of curves included as page 54 and the table on page 55 show the kilowatt-hours per consumer for domestic use and for commercial lighting, and also the number of horse-power per power consumer served by the Corporation of

This being the only figure available up to time this is in important in plot diagrams for kilowatt-hour consumption or costs, and the only reliability is in some as analysis of publicity in the 1921 price cost of the actual horse-power consumed and the kilowatt-hours for 1921. The figures are as follows:

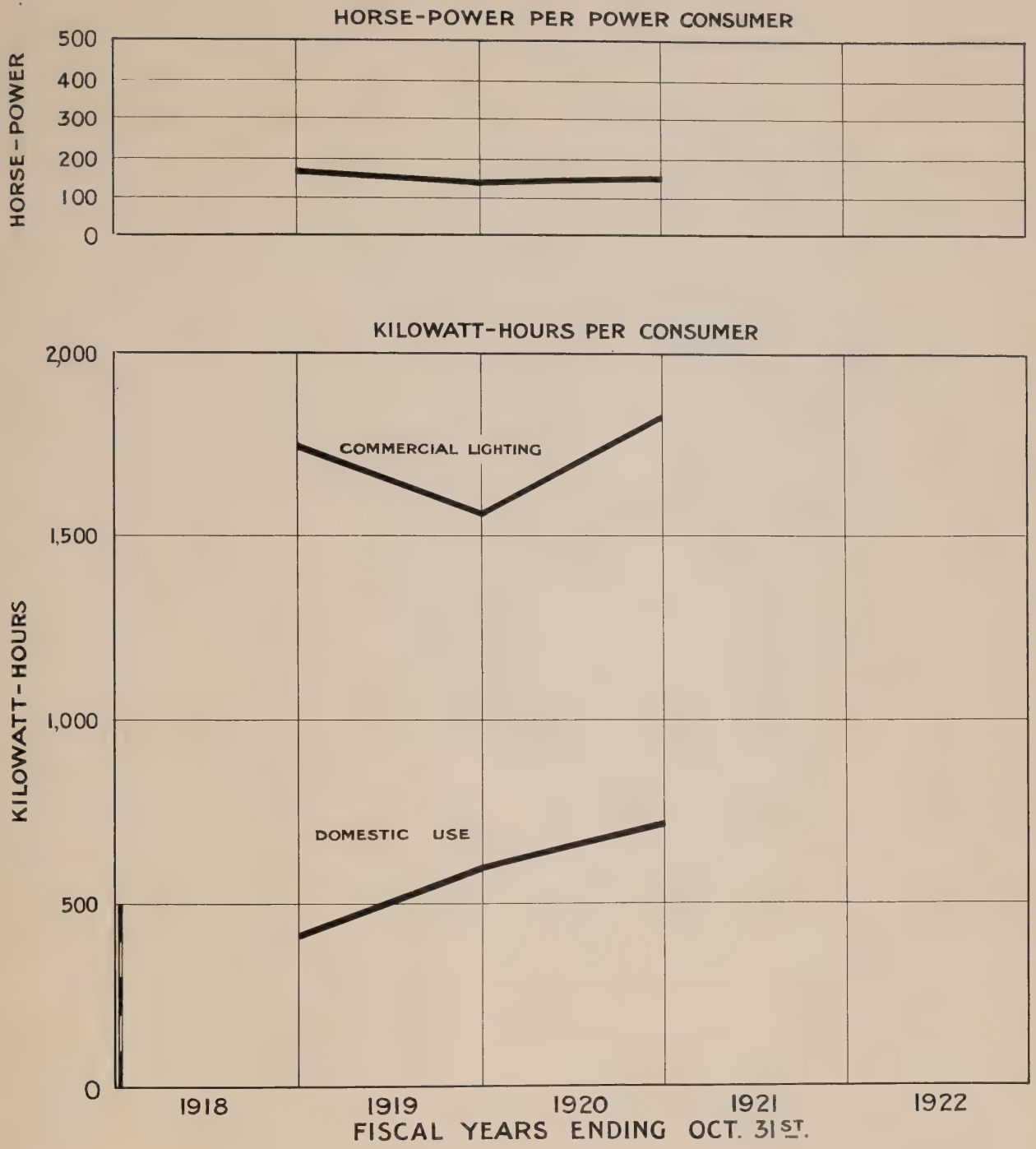
Ratio of Individual Costs per Average Horse-power and per Kilowatt-hour Consumed in 1921

	Dollars per H.P.	Cents per Kilowatt-hour
Power Purchased	1.141	[illegible]
Repairs	[illegible]	0.477
Maintenance	[illegible]	[illegible]
Overhead and General Expense	2.46	0.028
Interest	32.42	0.028
Renewals	-	-
Sinking Fund	-	-
Contingencies	-	-
Total	[illegible]	[illegible]

In the final summary for the Crown and in comparing the year 1921 with 1920, the payment per average horse-power and per kilowatt-hour would be the same as the total in the table above.

The total of the kilowatt-hours generated in the Mitchell power station is stated to have been 60,302,000.

The plant of Mr. [illegible] is one of the most [illegible] kilowatt-hours per annum for Kamaris was one of the [illegible] in the [illegible] of [illegible] the [illegible] at



HYDRO-ELECTRIC INQUIRY COMMISSION
W. D. GREGORY, CHAIRMAN

ECONOMICS OF H. E. P. C. DISTRIBUTION SYSTEMS

THUNDER BAY SYSTEM

H.P. PER POWER CONSUMER AND KILOWATT-HOUR CONSUMPTION

Toronto, June 20th., 1923. Made by S.R.W., Checked by W.D.A.

WALTER J. FRANCIS & COMPANY
CONSULTING ENGINEERS

the City of Port Arthur during the years 1918, 1919 and 1920.

Table of Various Classes of Power Consumption by the Corporation of the City of Port Arthur

	Calendar Years		
	1918	1919	1920
K.W.H. per Domestic Consumer	415	510	522
K.W.H. per Commercial Light Consumer	1,715	1,563	1,827
Horse-power per Power Consumer	166	145	152

Summary.

A summary of a number of the more salient points which have been studied and discussed in the foregoing report may be of advantage in concluding the consideration of the economics of the Thunder Bay System. They are as follows:

(1) The capital costs of the Thunder Bay System are very high considering the capacity presently installed in the plant. This, in part, is due to the fact that the construction work was carried on at a time when material and labour costs were high and, in part to the fact that the work was rushed in order to have the plant in operation when the contract between Port Arthur and the Kaministikwia Power Company lapsed. Another reason for the present high cost is that some parts of the development have been completed for the ultimate capacity of the plant, that is, to provide for six generating units, while as yet only two have been installed. It is estimated that the capital cost of the complete development will amount to about $13,000,000.

(2) For the reasons given above the capital cost per horse-power developed is at present very high, amounting to $285.22 at October 31st, 1921, but it is estimated that it will be reduced to about $190.00 when the six machines will have been installed and the requisite transmission lines provided.

(3) The annual cost per horse-power developed, as shown for the fiscal year ending October 31st, 1921, is $9.60, including all charges up to the point of delivery to Port Arthur. This is low, but it is based on the

nominal capacity of the two units in operation, whereas the horse-power billed in that year was less than the capacity of one generator. In this connection it must be noted that interest is charged only at a five per cent. rate and only on one-half of the capital cost of the development. In addition, no sums have been laid aside as reserves for renewals, sinking fund nor contingencies. Further, it is not apparent that any payments have been made on account of water rentals.

(4) The annual cost per horse-power billed in 1921 was $20.67. This should be largely increased to provide reserves for renewals, sinking fund and contingencies and to cover the amount payable for water rentals. The interest charge included in this cost was sufficient to pay only five per cent. on one-half of the investment in the new development as noted above.

(5) It would seem to be advisable to establish a proper basis for building up the reserves for renewals, sinking fund and contingencies, even if their collection should be deferred for a time until the load on the System will have increased to the capacity of the present installation.

(6) A study of the economic future of the Nipigon System has been made by Mr. Walter J. Francis and presented to the Hydro-Electric Inquiry Commission in two reports dated September 2nd, 1922, and September 18th, 1922, to which reference may be made.

Walter J. Francis
Consulting Engineer.

Toronto, June 20th, 1923.

[illegible]

[illegible]

[illegible]